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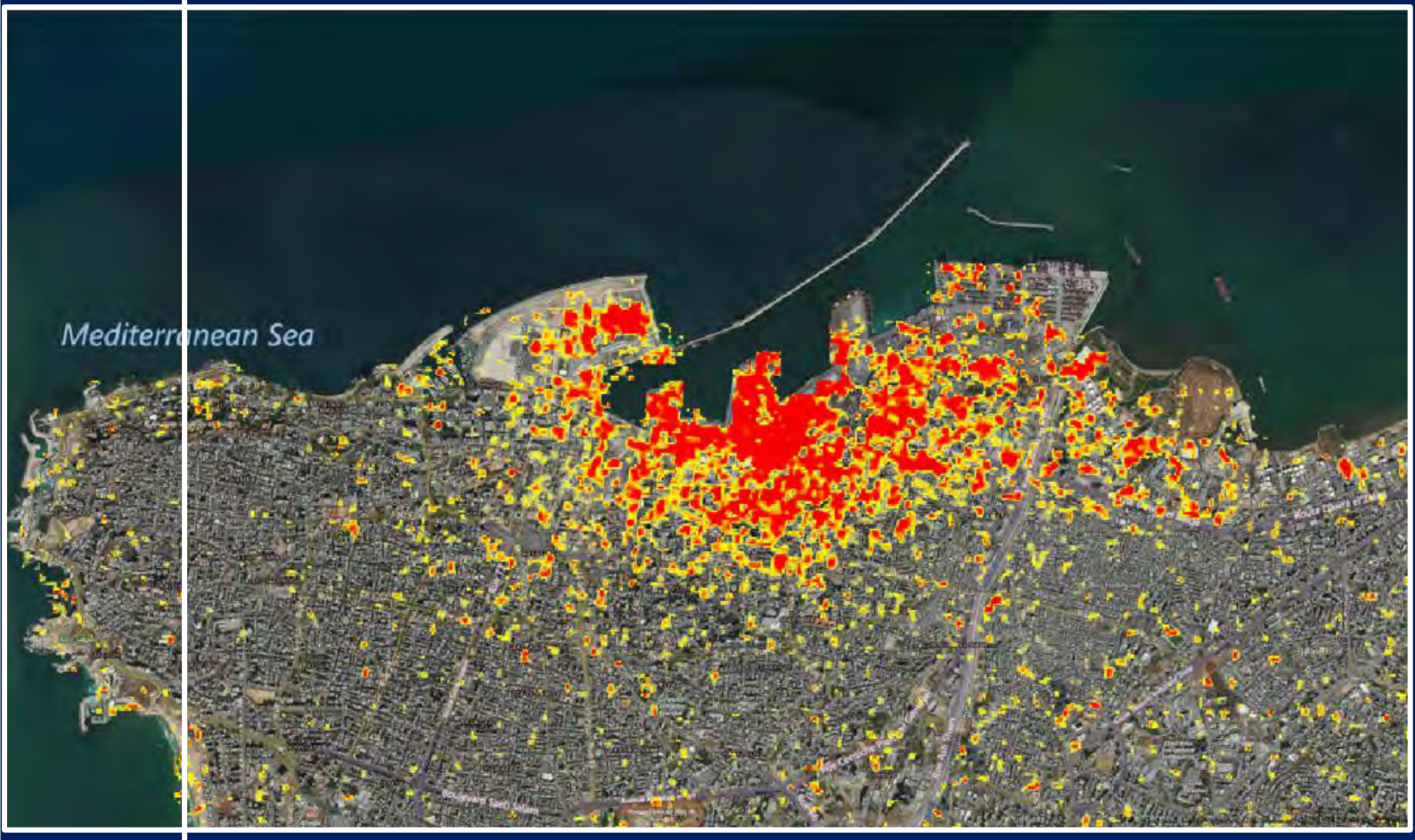

TRAINING KIT – HAZA08

DAMAGE ASSESSMENT WITH SENTINEL-1 & SENTINEL-2 – AUGUST 2020 (Beirut, LEBANON)

serco NOVELTIS ALONG-TRACK ROMANIA

Research and User Support for Sentinel Core Products

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Authors would be glad to receive your feedback or suggestions and to know how this material was used. Please, contact us on training@rus-copernicus.eu

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Table of Contents

1 Introduction

The Research and User Support for Sentinel core products (RUS) service provides a free and open scalable platform in a powerful computing environment, hosting a suite of open source toolboxes pre-installed on virtual machines, to handle and process data acquired by the Copernicus Sentinel satellites constellation.

View of the Beirut port and surroundings in Lebanon, before (image above) and after (image below) the explosion, on August 4th, 2020. (Source: Google Earth)

On 4 August 2020 in Lebanon, at around 17:55 local time (14:55 UTC), a fire broke out in Warehouse 12 at the Port of Beirut, where a cargo of 2,750 tonnes of ammonium nitrate was stored, followed by 2 explosions a few minutes later.

The first explosion produced a large cloud of smoke, damaging heavily the warehouse, while the second that was caused by nitrogen dioxide, a byproduct of ammonium nitrate decomposition, produced a red-orange cloud surrounded by a white condensation cloud.

The consequences were severe in many fields and levels. It is estimated that more than 200 people lost their lives, 6,500 were injured and 300,000 people went homeless since homes as far as 10 km away were damaged. The blast affected over half of Beirut, with the cost to be above $15 billion in property damages.

Within the port area, the explosion destroyed a section of shoreline leaving a crater around 124m in diameter and 43m in depth. Experts estimated that the explosion was one of the biggest non-nuclear explosions in history, it was detected as a seismic event of magnitude 3.3.

It was felt in many countries such as Turkey, Syria, Israel, Palestine and parts of Europe, and was heard in Cyprus, more than 240 km away. The Lebanese government declared a two-week state of emergency in response to the disaster.

2 Training

Approximate duration of this training session is **two** hours.

The Training Code for this tutorial is HAZA08. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the RUS portal to request a Virtual Machine. Go to Your RUS Service → Your training activities and *Request a Webinar Training*.

2.1 Data used

- Three Sentinel-1 IW SLC images acquired on 25 July 2020, 31 July 2020 and 6 August 2020 [downloadable at https://scihub.copernicus.eu/]

  S1B_IW_SLC__1SDV_20200725T033445_20200725T033512_022622_02AEEE_A0BA
  S1A_IW_SLC__1SDV_20200731T033531_20200731T033558_033693_03E7B2_D1A9
  S1B_IW_SLC__1SDV_20200806T033445_20200806T033512_022797_02B43D_3A0B

- Two Sentinel-2 Level 2A images (Tile ID: T36SYC) acquired on 24 July 2020 and 18 August 2020 [downloadable at https://scihub.copernicus.eu/]

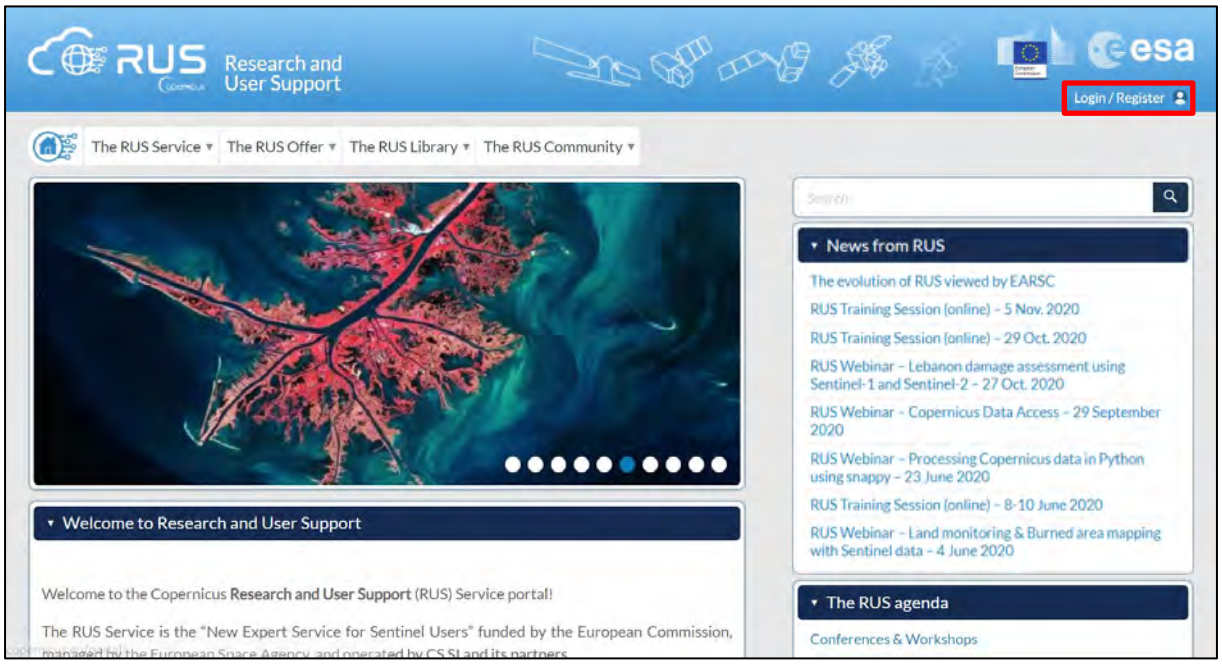
  S2A_MSIL2A_20200724T081611_N0214_R121_T36SYC_20200724T110803
  S2B_MSIL2A_20200818T081609_N0214_R121_T36SYC_20200818T110855

2.2 Software in RUS environment

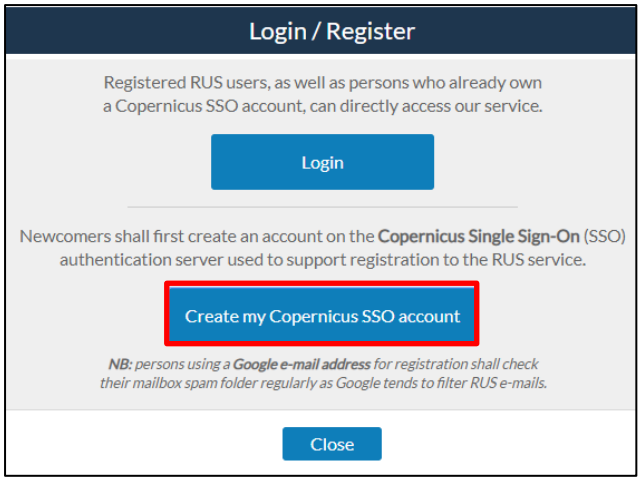
Internet browser, SNAP + Sentinel-1 and Sentinel-2 Toolboxes, QGIS.

3 Register to RUS Copernicus

To repeat the exercise using a RUS Copernicus Virtual Machine (VM), you will first have to register as a RUS user. For that, go to the RUS Copernicus website (www.rus-copernicus.eu) and click on ***Login/Register*** in the upper right corner.

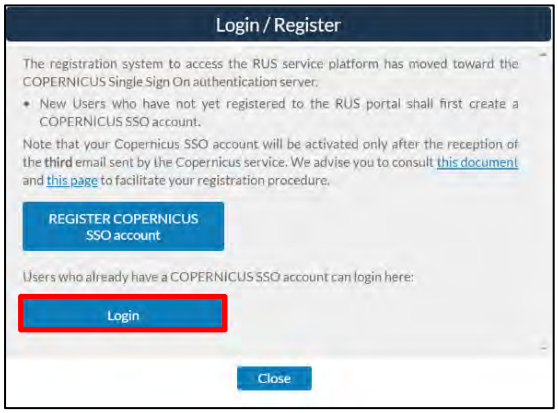


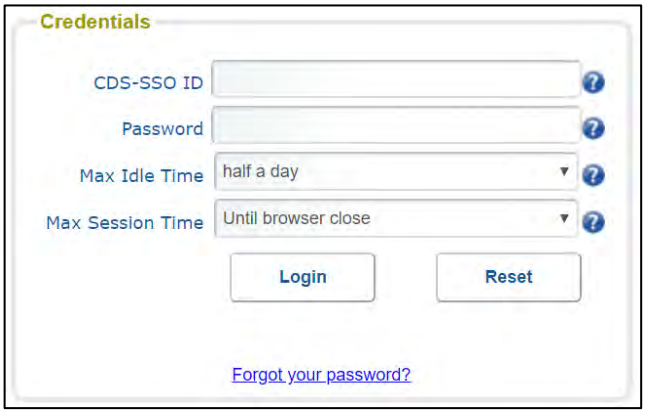
Select the option ***Create my Copernicus SSO account*** and then fill in ALL the fields on the **Copernicus Users' Single Sign On Registration**. Click ***Register***.



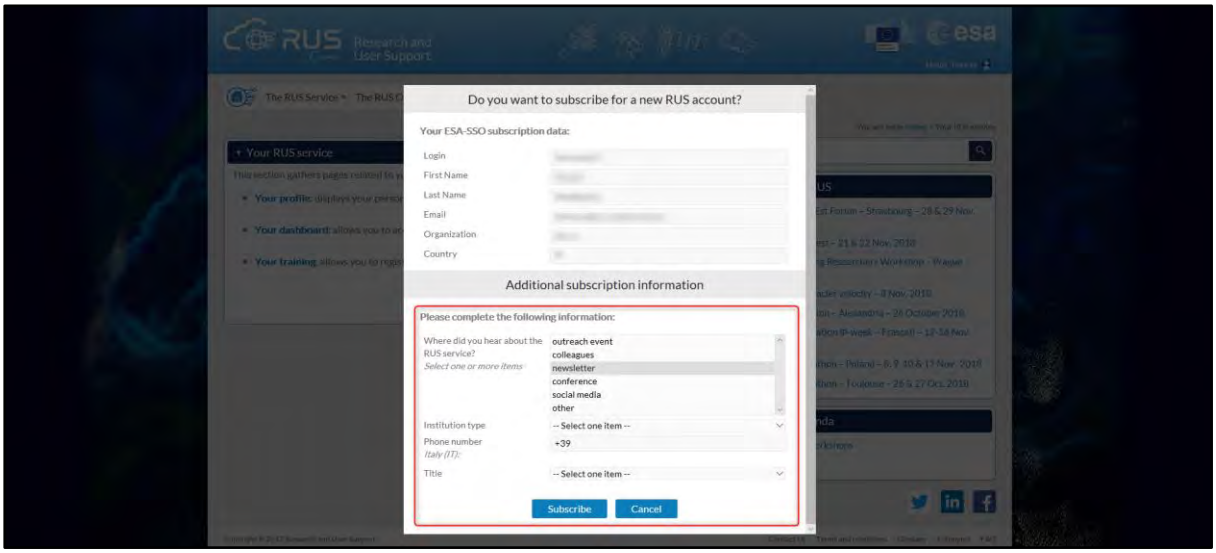
Within a few minutes you will receive an e-mail with activation link. Follow the instructions in the e-mail to activate your account.

You can now return to https://rus-copernicus.eu/, click on ***Login/Register***, choose ***Login*** and enter your chosen credentials.



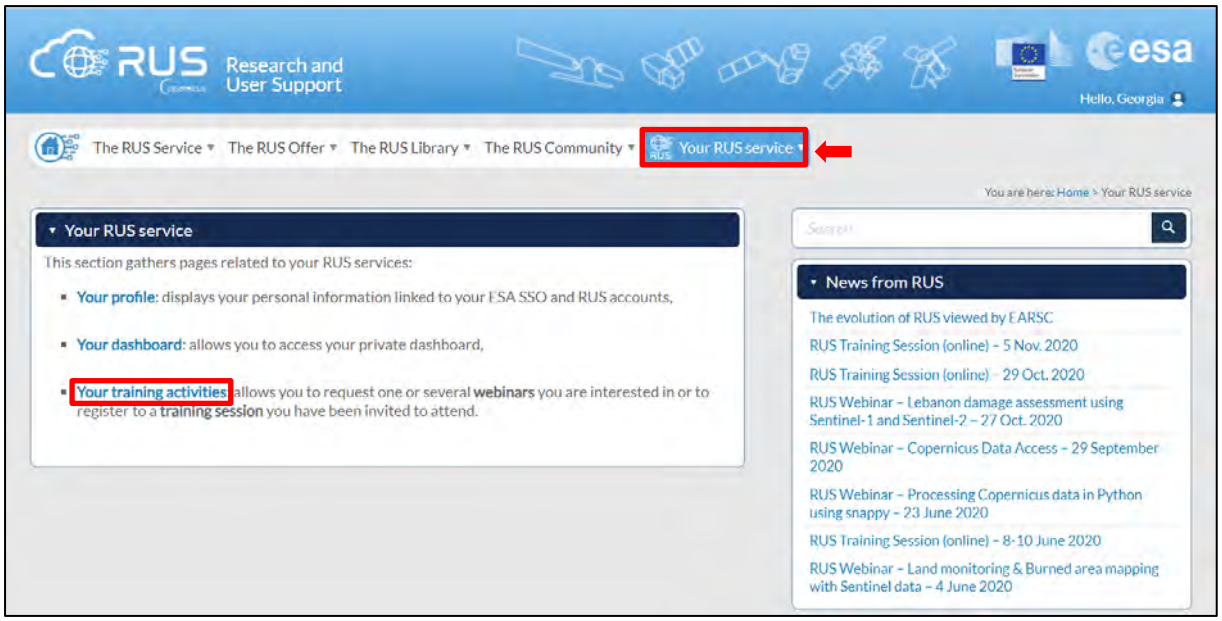


Upon your first login you will need to enter some details. You must fill all the fields.

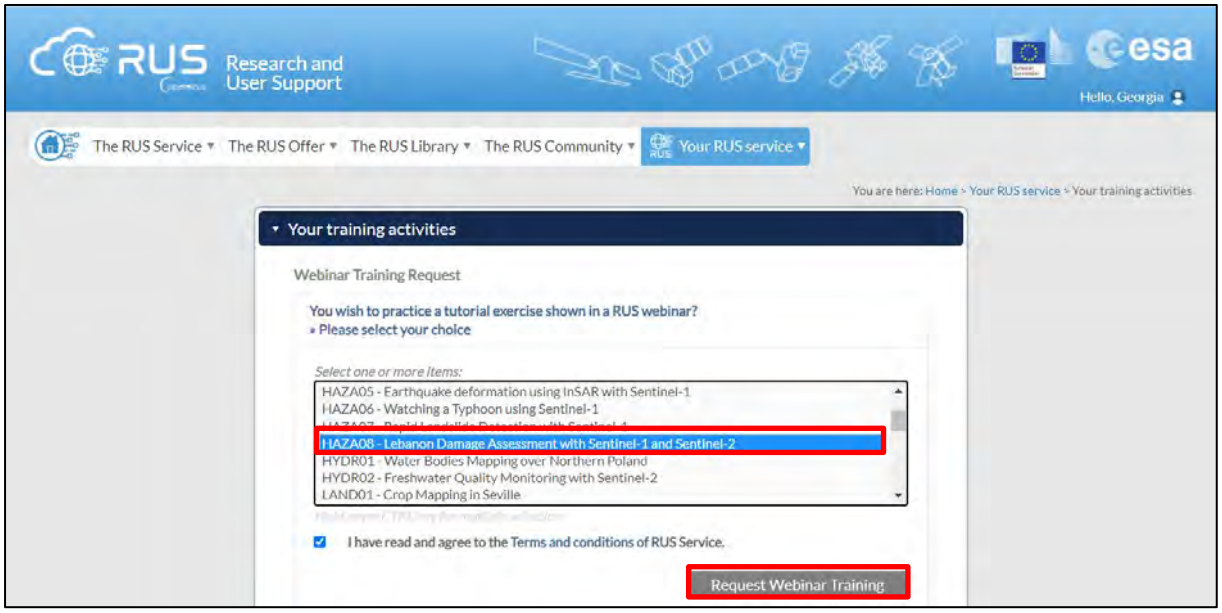


4 Request a RUS Copernicus Virtual Machine to repeat a Webinar

Once you are registered as a RUS user, you can request a RUS Virtual Machine to repeat this exercise or work on your own projects using Copernicus data. For that, log in and click on ***Your RUS Service → Your training activities***.

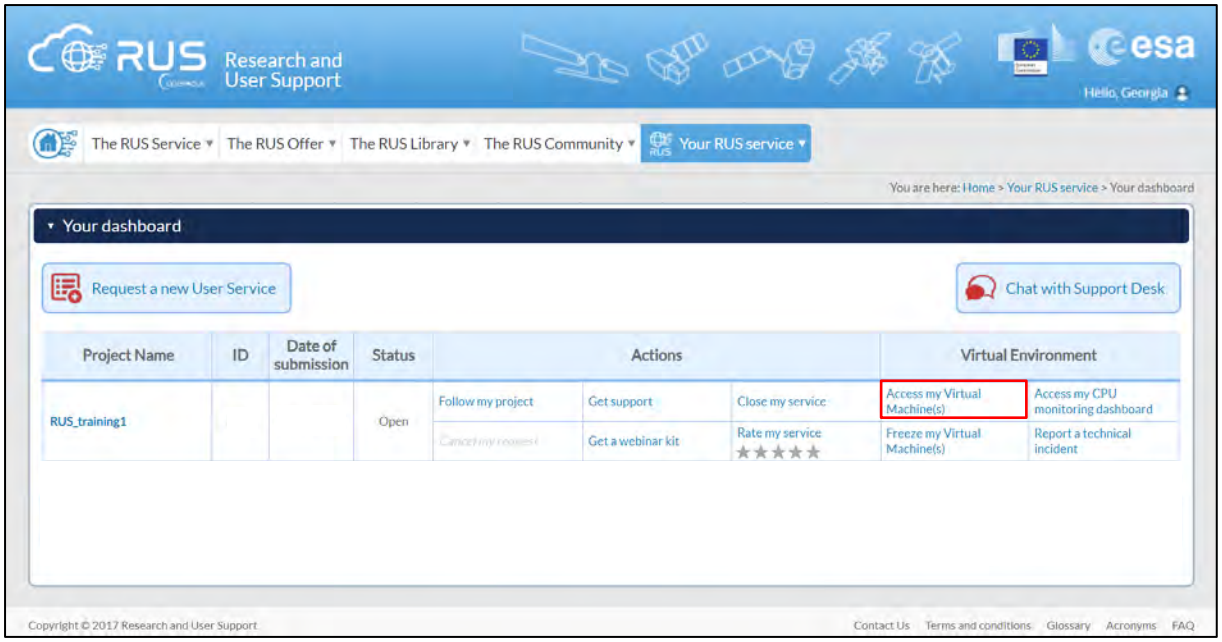


Select **HAZA08 - Lebanon Damage Assessment with Sentinel-1 & Sentinel-2**, check the field *"I have read and agree to the Terms and conditions of RUS Service"* and then click on ***Request Webinar Training*** to request your RUS Virtual Machine.



Further to the acceptance of your request by the RUS Helpdesk, you will receive a notification email with all the details about your Virtual Machine.

To access it, go to ***Your RUS Service → Your Dashboard*** and click on ***Access my Virtual Machine***.



Fill in the login credentials that have been provided to you by the RUS Helpdesk via email to access your RUS Copernicus Virtual Machine.

This is the remote desktop of your Virtual Machine.

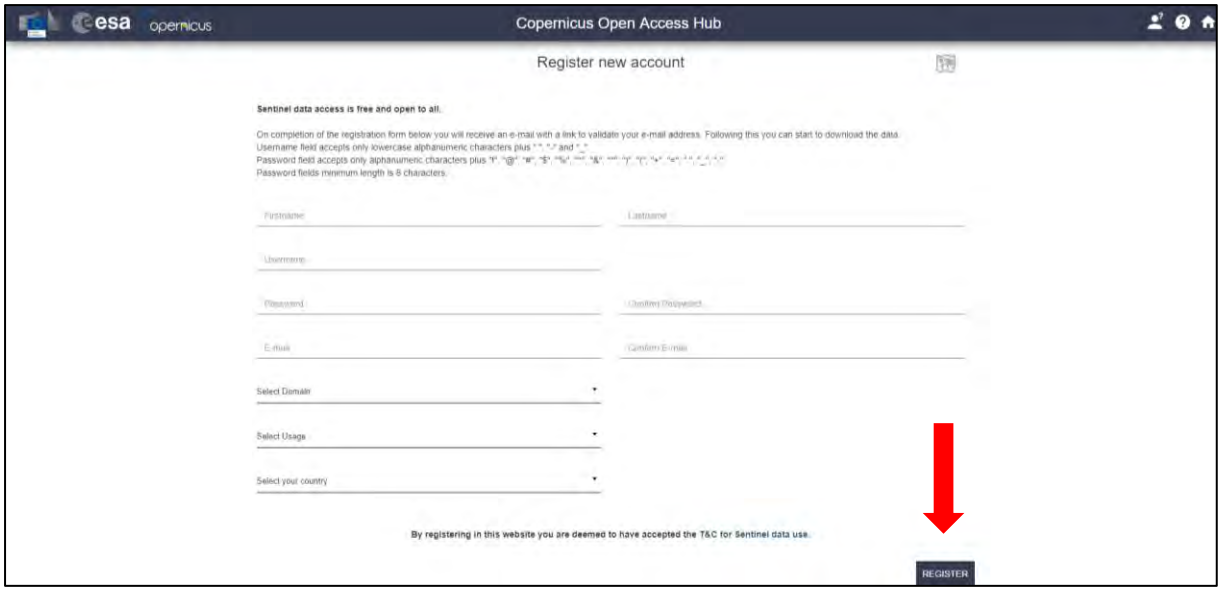
5 Step by step

5.1 Data download – ESA SciHUB

In this step, we will download the Sentinel-1 and Sentinel-2 scenes we will use for the exercise, from the Copernicus Open Access Hub using the online interface. Go to **Applications → Network → Firefox Web Browser** or click the link below.

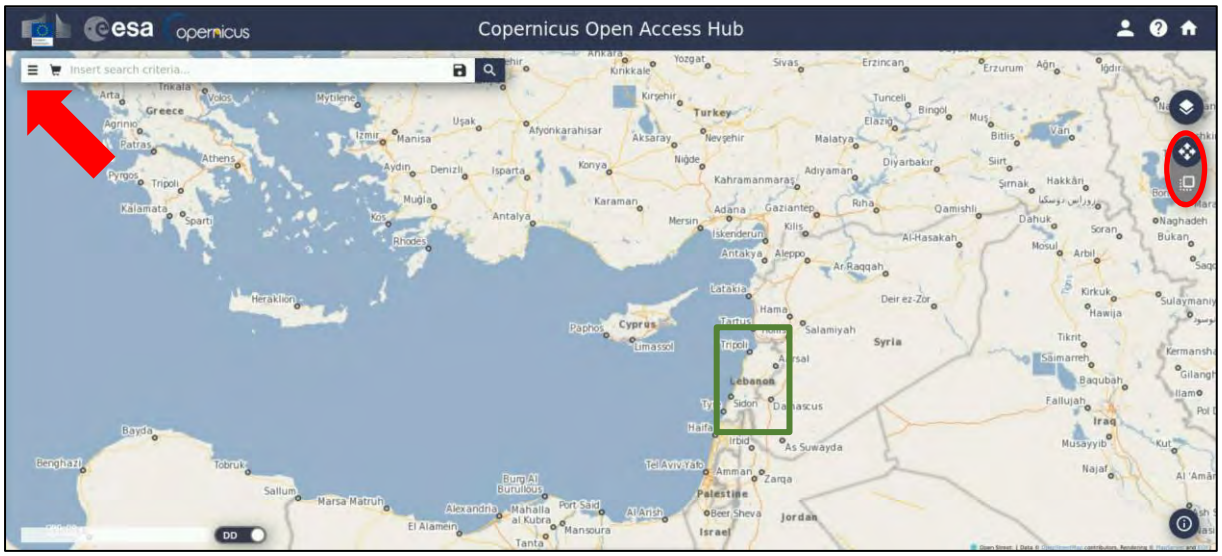
Go to https://scihub.copernicus.eu/

Go to "**Open HUB**", if you do not have an account please register by going to "**Sign-up**" in the LOGIN menu in the upper right corner.



After you have filled in the registration form, you will receive an activation link by e-mail. Once your account is activated or if you already have an account, "**LOGIN**".

Navigate over Lebanon, eastern Mediterranean Sea (**approximate area – green rectangle**).

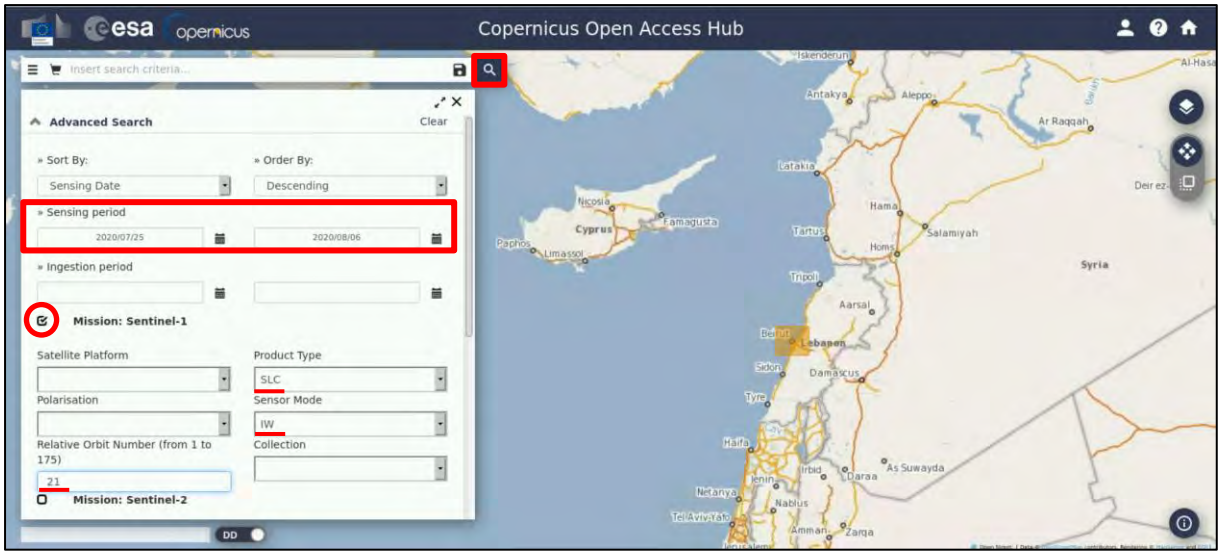


We need to download 3 Sentinel-1 images over the area of interest, two before the event and one after it.

Zoom in a bit more, switch to "**drawing mode**" and draw a search rectangle approximately as indicated below. Open the search menu by clicking to the left part of the search bar. We will specify at once the parameters for both products before the date of the explosion and for the one afterwards as well:

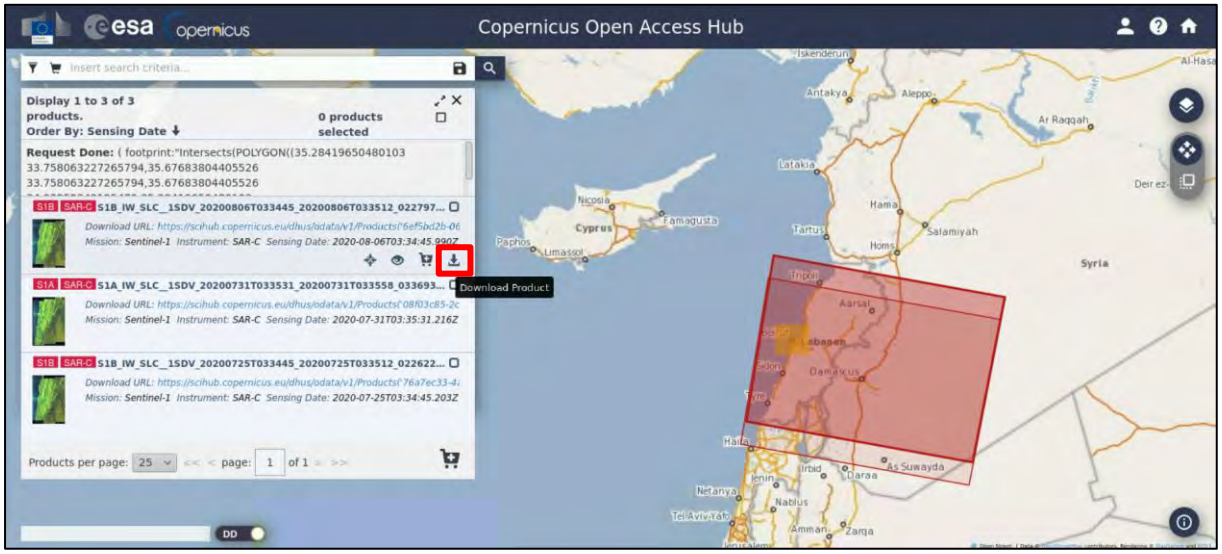
<u>For Sentinel-1:</u>

Sensing period: From 2020/07/25 to 2020/08/06
Select: Mission: Sentinel-1
Product Type: SLC
Sensor Mode: IW
Relative Orbit Number: 21



Then click on the "**Search**" icon. The search returns 3 results for the time period we set. We need to download them all, so we click on the "**Download Product**" icon of each one:

S1B_IW_SLC__1SDV_20200725T033445_20200725T033512_022622_02AEEE_A0BA
S1A_IW_SLC__1SDV_20200731T033531_20200731T033558_033693_03E7B2_D1A9
S1B_IW_SLC__1SDV_20200806T033445_20200806T033512_022797_02B43D_3A0B

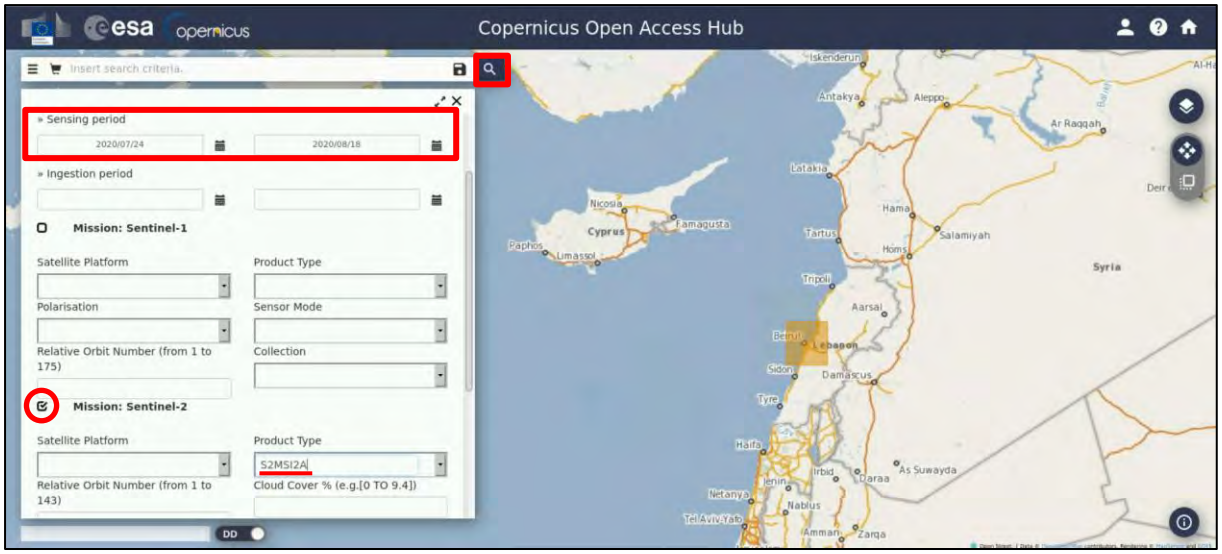


NOTE 1: Please keep in mind that you cannot download more than 2 products at the same time, per account from SciHub.

Return to the search menu and set the parameters for the two Sentinel-2 products we will need, one before and one after the explosion. **Deselect** Sentinel-1 mission and apply the following steps.

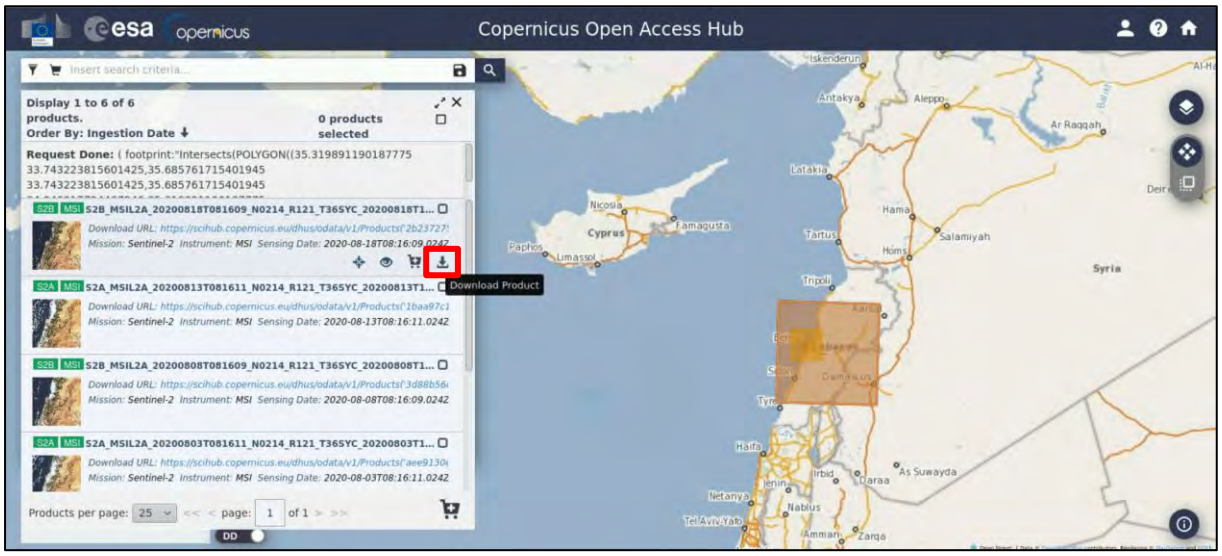
For Sentinel-2:

Sensing period: From 2020/07/24 to 2020/08/18
Select: Mission: Sentinel-2
Product Type: S2MSI2A



Then click on the "**Search**" icon. The search returns 6 results for the time period and the area we set. If you draw a larger rectangle, you will have more results when searching. Download only the two following images by clicking on the "**Download Product**" icon:

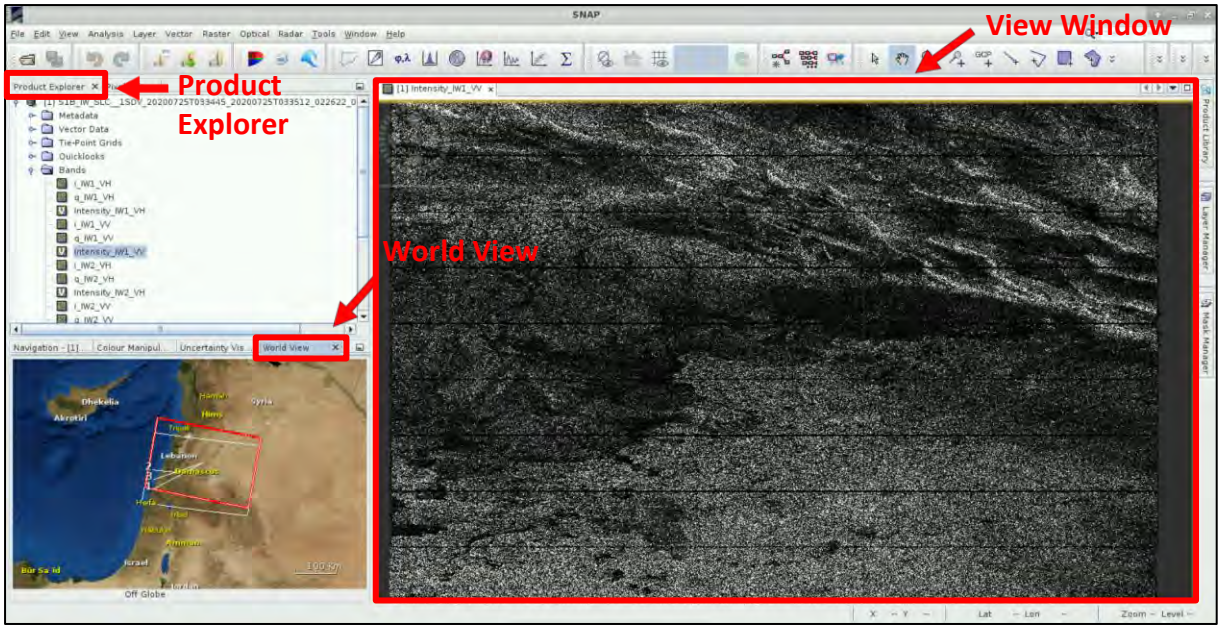
S2A_MSIL2A_20200724T081611_N0214_R121_T36SYC_20200724T110803
S2B_MSIL2A_20200818T081609_N0214_R121_T36SYC_20200818T110855



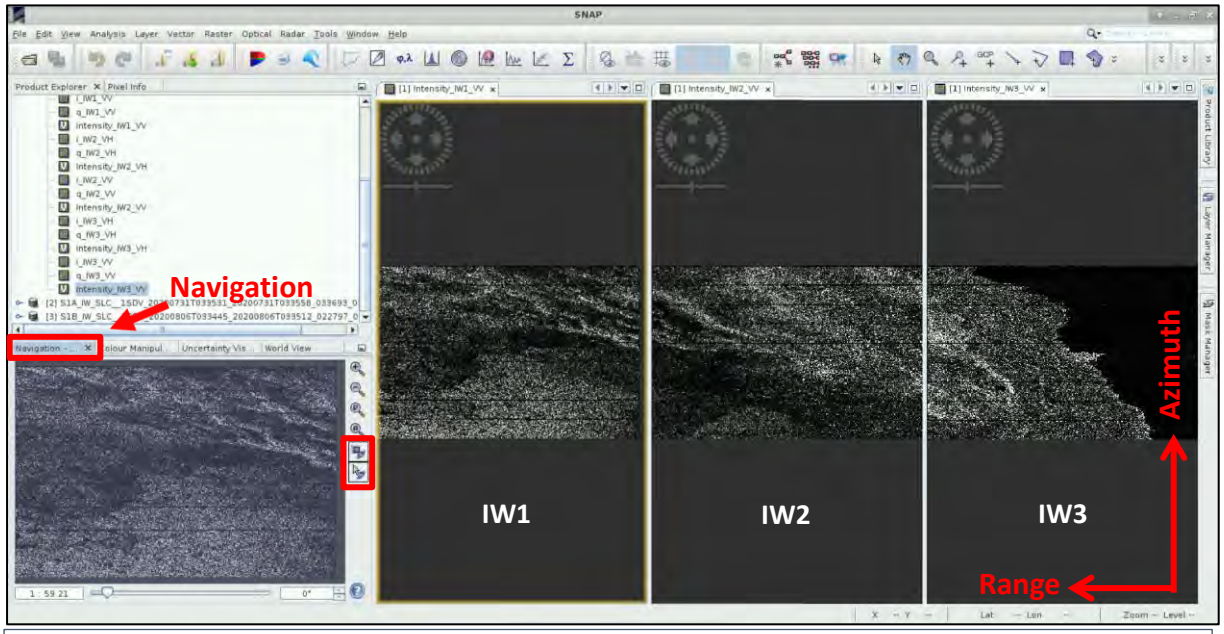
The products will be downloaded at ***/home/rus*** as zip files. Move them to: ***/shared/Training/HAZA08_LebanonDamageAssessment/Original*** folder.

5.2 SNAP – open and explore data

Open **SNAP** software from the icon located on the desktop or go to **Applications → Processing → SNAP Desktop**. Click the **Open Product** icon, navigate to: ***/shared/Training/HAZA08_LebanonDamageAssessment/Original*** folder and open all Sentinel-1 products (from oldest to the most recent). Alternatively, open a folder in your VM, navigate to the path mentioned above, drag the products from the folder one by one and drop them to the **Product Explorer** Window (first the **20200725**, then the **20200731** and last the **20200806**). The opened products will appear in **Product Explorer** window. Click **+** or to expand the contents of product **[1]** from **25 July 2020**, then expand **Bands** folder and double click on ***Intensity_IW1_VV*** band to visualize it in the **View** window. You can go to the **World View** tab and zoom in to see the location of the opened product on the globe (See NOTE 2).



Open the ***Intensity_IW2_VV*** and ***Intensity_IW3_VV*** bands as well, and go to **Window → Tile Horizontally.** Go to the **Navigation** tab and click on the two icons shown within the red rectangular below, to synchronize the views and the cursor position between the views. (See NOTE 3).



NOTE 2: The Interferometric Wide (IW) swath mode captures three sub-swaths using Terrain Observation with Progressive Scans SAR (TOPSAR). IW SLC products contain one image per sub-swath and one per polarisation channel, for a total of three (single polarisation) or six (dual polarisation) images in an IW product. Each sub-swath image consists of a series of bursts, where each burst has been processed as a separate SLC image. The images for all bursts in all sub-swaths are resampled to a common pixel spacing grid in range and azimuth while preserving the phase information. *(Source: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/acquisition-modes/interferometric-wide-swath)* The Beirut port is located on the IW3 sub-swath of the selected images.

NOTE 3: The RADAR instrument onboard Sentinel-1 carries an antenna that is looking always to the right during its pass. These two scenes were acquired during **descending** pass (the satellite was moving in direction from north to south). That is why we see that the view of the image appears as if "mirrored", because the view shows the pixels in order of the data acquisition.

5.3 *Sentinel-1 Processing – Part 1*

We will use the **GraphBuilder** tool, to create a chain with the steps of the processes we want to apply and at the end, only the final product will be physically saved (this way we will also save disk space since the products of the intermediate steps will not be stored).

In this part, we will reach up to the step where we will use two pairs of Sentinel-1 images, in order to create two coregistered products. The first pair will consist of the two images before the event, and the second pair will consist of the one image right before the event and the other one after it.

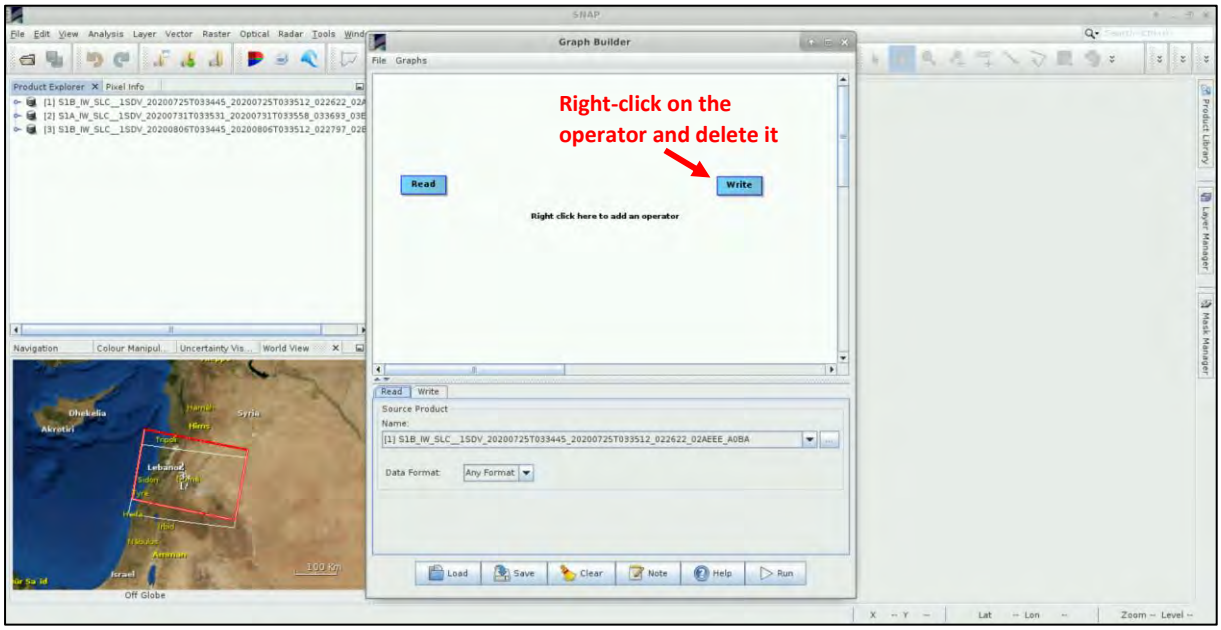
5.3.1 Graph Builder

Go to **Tools** → **GraphBuilder** to build our graph.

We can see that the graph has only two operators: **Read** (to read the input) and **Write** (to write the output). Below there also are the corresponding to the operators' tabs.

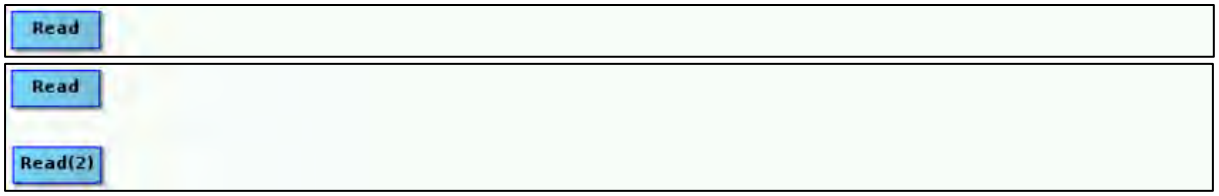
Right-click on the **Write** operator and **Delete** it. The corresponding tab will be removed as well. This is to avoid confusion to the sequence of the graph. The **Write** operator will be added again at the end.

For now, we will not define any parameters in the tabs, we will first create the graph and then we will go tab by tab to insert the desired parameters. Follow the instructions written in black to build the graph and once it is ready, go back and insert the parameters written in purple. There will be a reminder and further instructions when you reach that step.

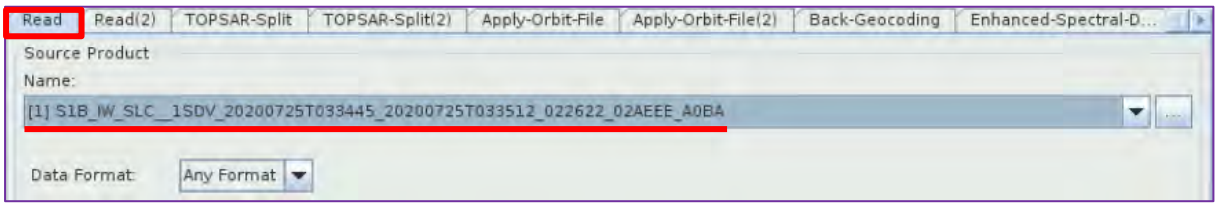


5.3.2 Read the input products

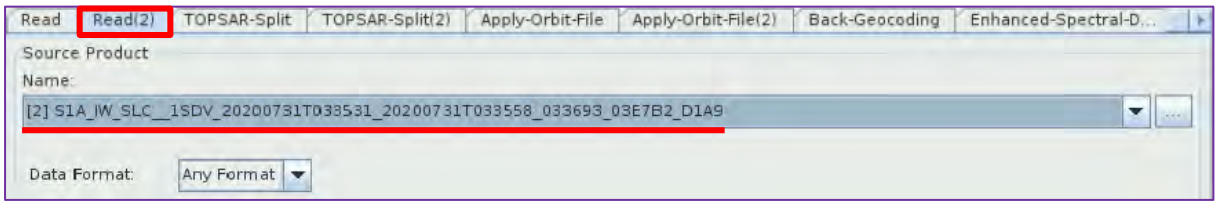
There is only one **Read** operator in the graph (for the first product of the pair) and we will add one more, for the second product of the pair. Right-click at the empty white space below the **Read** operator and go to **Add → Input-Output → Read**. The **Read(2)** operator will be created. Place it below **Read**.



In the **Read** tab, as Source Product, select the product with Name:
S1B_IW_SLC__1SDV_20200725T033445_20200725T033512_022622_02AEEE_A0BA



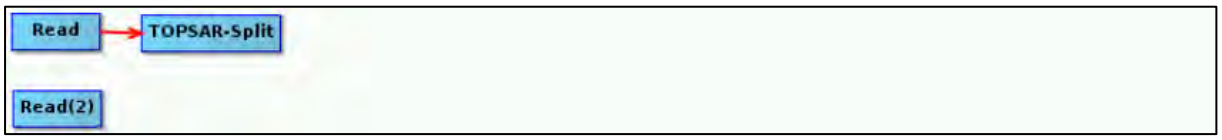
In the **Read(2)** tab, as Source Product, select the product with Name:
S1A_IW_SLC__1SDV_20200731T033531_20200731T033558_033693_03E7B2_D1A9



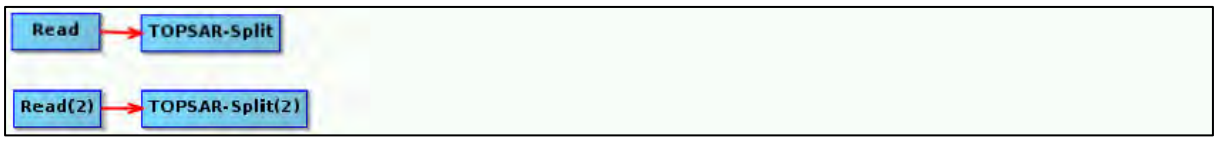
5.3.3 TOPS Split

Every Interferometric Wide swath (IW) consists of 3 sub-swaths and each one of maximum 9 bursts. In SNAP we can process only one swath at a time until the **Deburst** step. Our area of interest is located in the IW3 swath and is covered sufficiently by processing 2 bursts. We will use the **TOPSAR-Split** operator; this way we will reduce the total processing time.

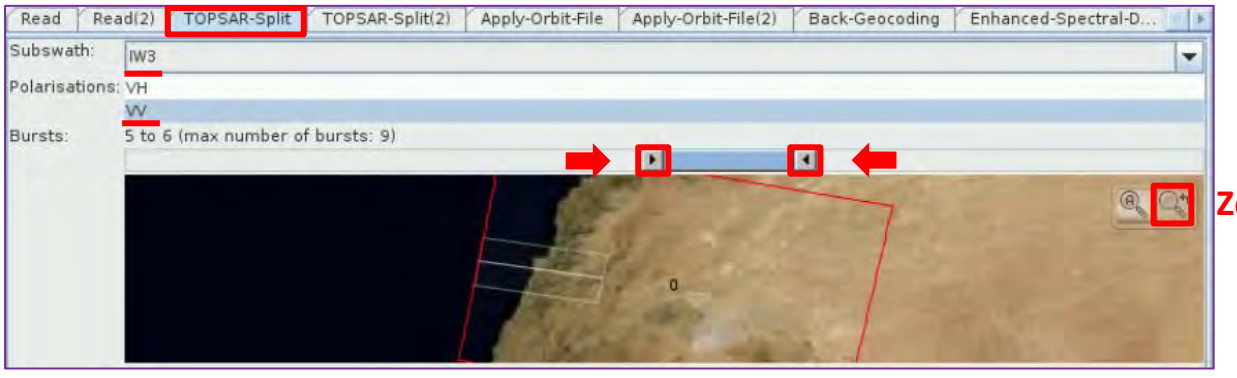
To add the **TOPSAR-Split** operator for the first product, right-click right of the **Read** operator and go to **Add → Radar → Sentinel-1 TOPS → TOPSAR-Split**. Connect the **Read** operator to it by dragging the red arrow from the right side of **Read** operator towards the **TOPSAR-Split** operator.



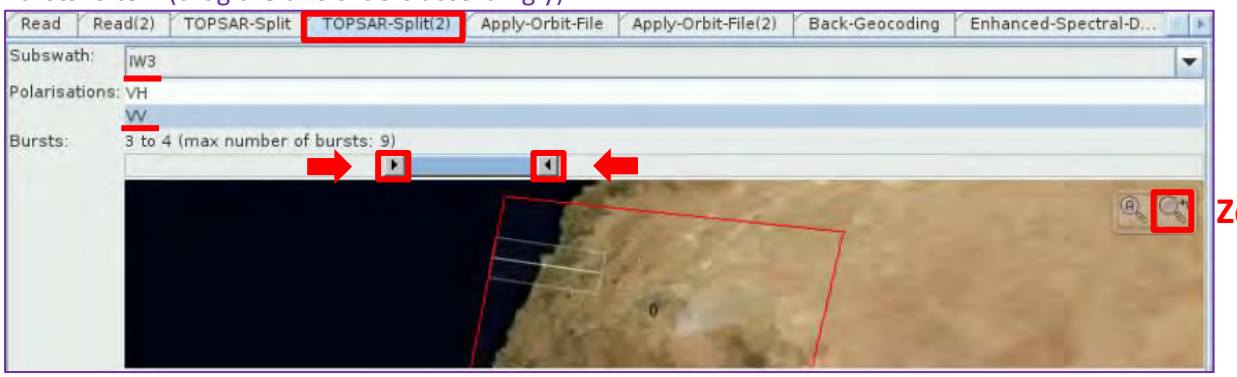
Repeat the same to add the **TOPSAR-Split(2)** operator and connect it with the **Read(2)** operator.



In the **TOPSAR-Split** tab, **Zoom in** to the product and select: **Subswath:** IW3, **Polarisations:** VV, **Bursts:** 5 and 6 (drag the two sliders accordingly).

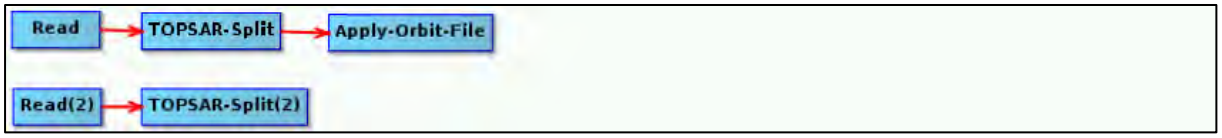


In the **TOPSAR-Split(2)** tab **Zoom in** to the product and select: **Subswath:** IW3, **Polarisations:** VV, **Bursts:** 3 to 4 (drag the two sliders accordingly).



5.3.4 Apply Orbit File

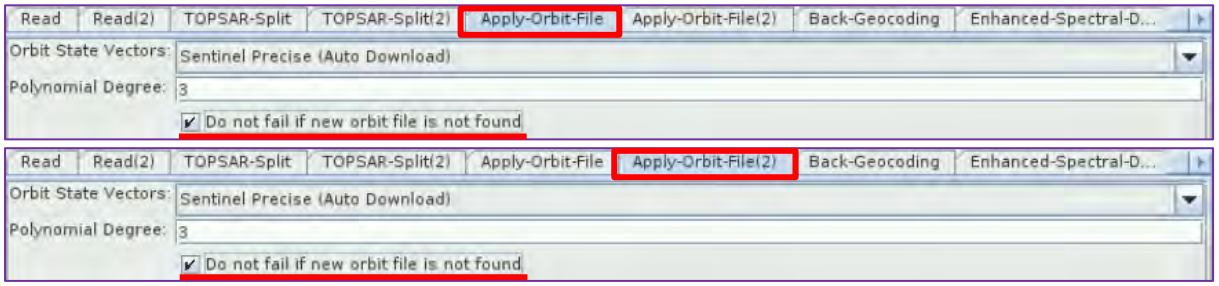
Next, we will apply the updated orbits to the products (See NOTE 4). Right-click and go to **Add → Radar → Apply-Orbit-File**. Connect the **TOPSAR-Split** operator to it.



Repeat the same to add the **Apply-Orbit-File(2)** operator and connect it with the **TOPSAR-Split(2)** operator.

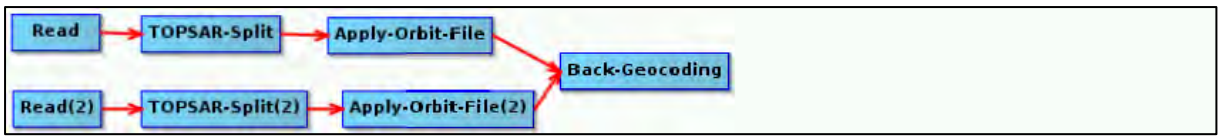
NOTE 4: The orbit state vectors provided in the metadata of a SAR product are generally not accurate and can be refined with the precise orbit files which are available days-to-weeks after the generation of the product. **The orbit file provides accurate satellite position and velocity information**. Based on this information, **the orbit state vectors in the abstract metadata of the product are updated**. (*SNAP Help*)

In both the **Apply-Orbit-File** tab and the **Apply-Orbit-File(2)** tab, we will keep the default settings, and make sure that you will **select** the "**Do not fail if new orbit file is not found**" option.

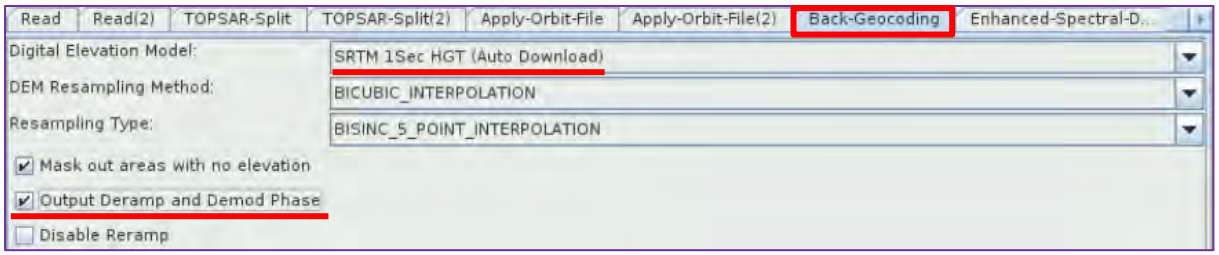


5.3.5 Back Geocoding

Now we will coregister the two products. Image coregistration is the alignment of master and slave images, the pixels of the slave images correspond to those of the master and represent an identical area. To add the **Back-Geocoding** operator right-click and go to **Radar → Coregistration → S-1 TOPS Coregistration → Back-Geocoding**. Connect both **Apply-Orbit-File** and **Apply-Orbit-File(2)** operators to it.



In the **Back-Geocoding** tab set: **Digital Elevation Model:** SRTM 1Sec HGT (Auto Download), **select** the "**Output Deramp and Demod Phase**" option as well and leave the rest parameters as by default.

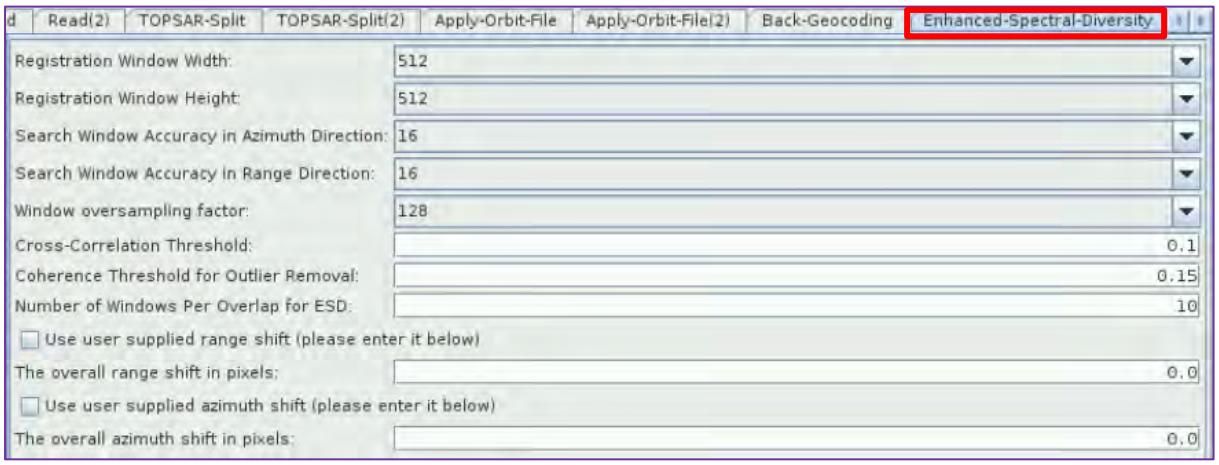


5.3.6 Enhanced Spectral Diversity

This operator follows the **Back-Geocoding** operator, it first estimates a constant range offset for each burst using a small block of data in the center of the burst and then it estimates a constant azimuth offset. Finally, the estimates from all bursts are averaged to get the final constant range and azimuth offset for the whole image.

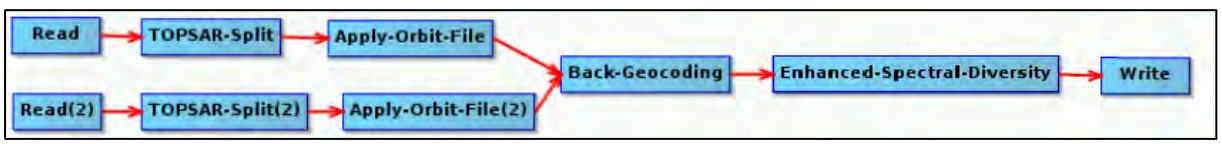
To add the **Enhanced-Spectral-Diversity** operator right-click and go to **Radar → Coregistration → S-1 TOPS Coregistration → Enhanced-Spectral-Diversity**. Connect the **Back-Geocoding** operator to it.

In the **Enhanced-Spectral-Diversity** tab keep all the default parameters.

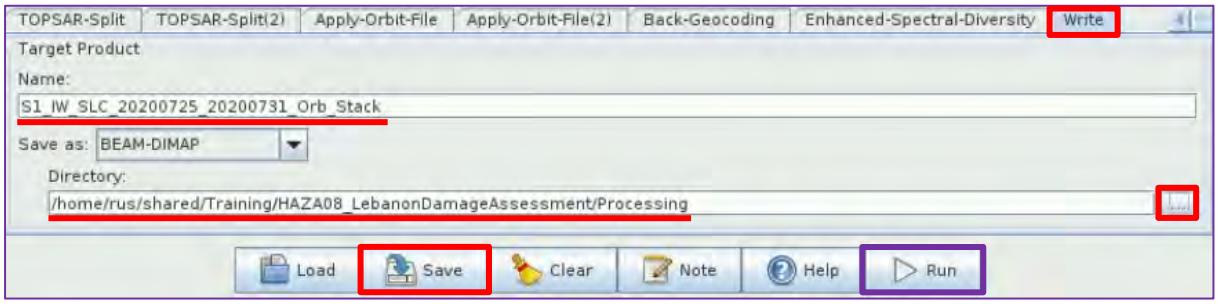


5.3.7 Write – create the output

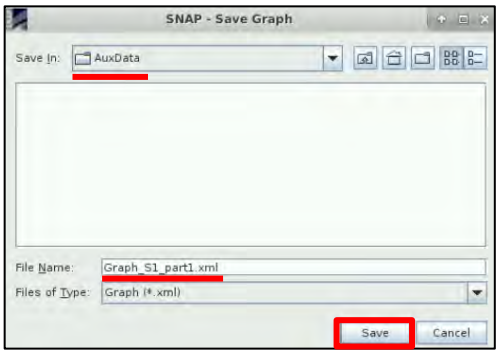
To add the **Write** operator right-click and go to **Add → Input-Output → Write**. Connect the **Enhanced-Spectral-Diversity** operator to it.



In the **Write** tab set the following:
Name: S1_IW_SLC_20200725_20200731_Orb_Stack
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing* (Click on the icon to set the appropriate path).



Click on the Save icon to save the graph for future use.



Go to the: */shared/Training/HAZA08_LebanonDamage Assessment/AuxData* folder and save it with the name: **Graph_S1_part1**.

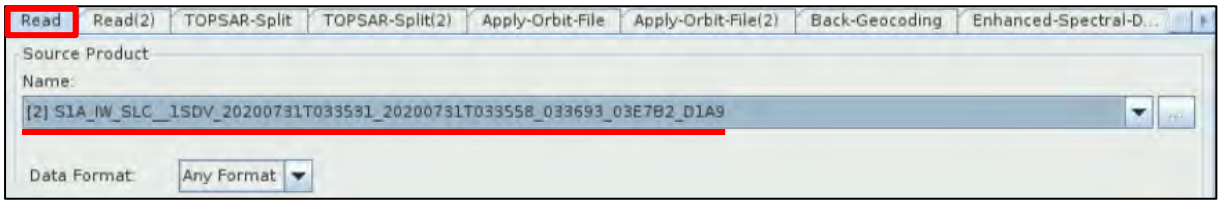
Now go all the way up to the purple parts of the chapters 5.3.2 to 5.3.7, fill the tabs with the appropriate parameters and finally click **Run**.

Once the processing is completed, the coregistered product will appear at the **Product Explorer** Window.

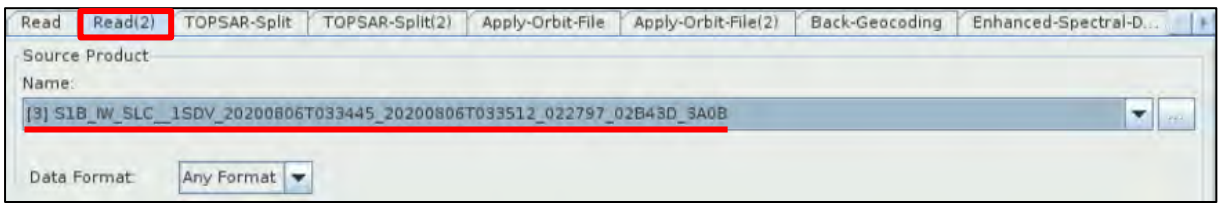
5.3.8 Repeat chapters 5.3.2 to 5.3.7

We will now keep the same graph we have built, opened, and we will go again tab by tab, to set the new parameters in each one, so that we create the coregistered product of the second pair of images.

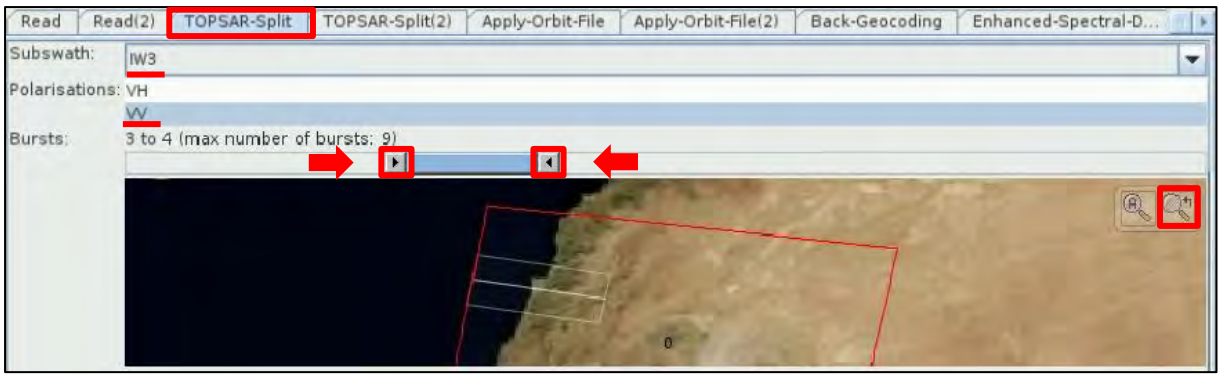
In the **Read** tab, as Source Product, select the product with Name:
S1A_IW_SLC__1SDV_20200731T033531_20200731T033558_033693_03E7B2_D1A9



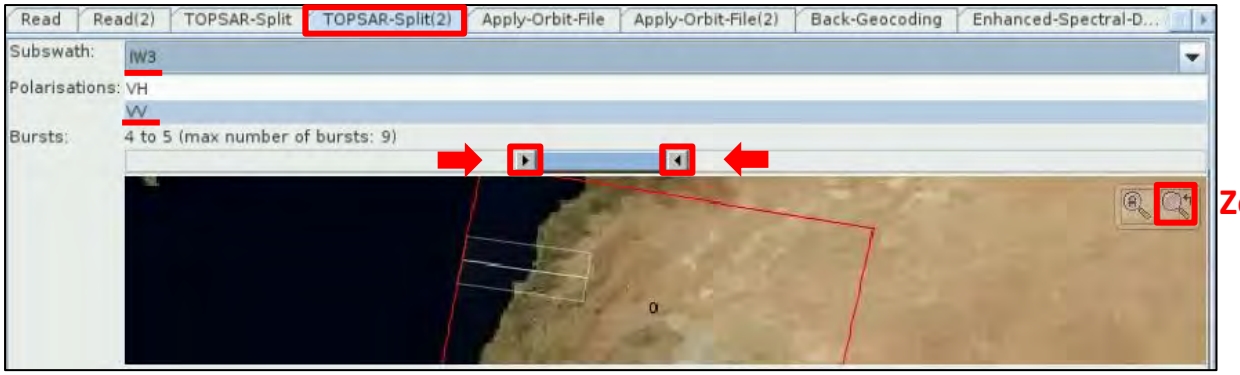
In the **Read(2)** tab, as Source Product, select the product with Name:
S1B_IW_SLC__1SDV_20200806T033445_20200806T033512_022797_02B43D_3A0B



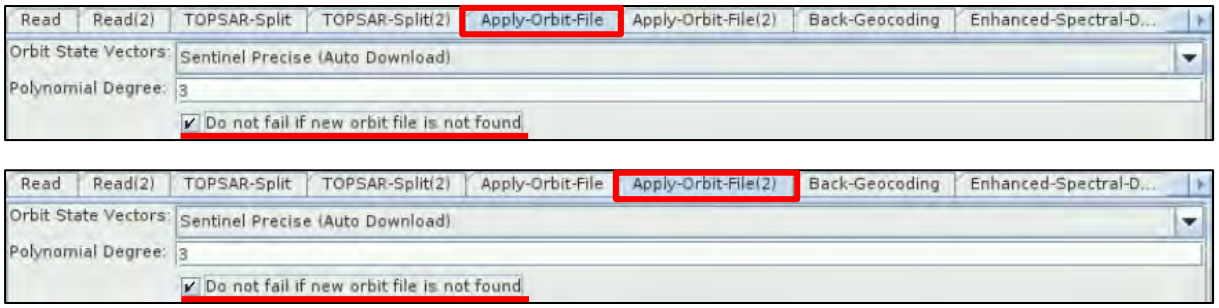
In the **TOPSAR-Split** tab **Zoom in** to the product and select: **Subswath:** IW3, **Polarisations:** VV, **Bursts:** 3 to 4 (drag the two sliders accordingly).



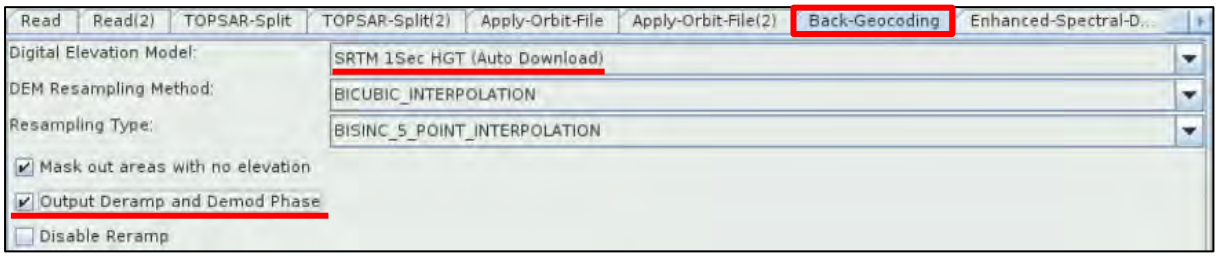
In the **TOPSAR-Split(2)** tab **Zoom in** to the product and select: **Subswath:** IW3, **Polarisations:** VV, **Bursts:** 4 to 5 (drag the two sliders accordingly).



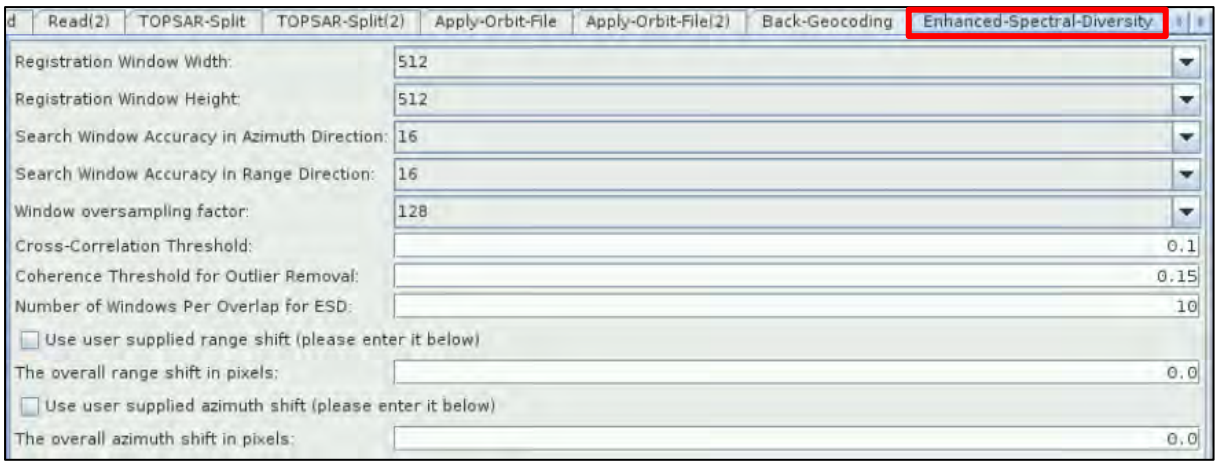
In both the **Apply-Orbit-File** tab and the **Apply-Orbit-File(2)** tab, we will keep the default settings, and make sure that you will **select** the "**Do not fail if new orbit file is not found**" option.



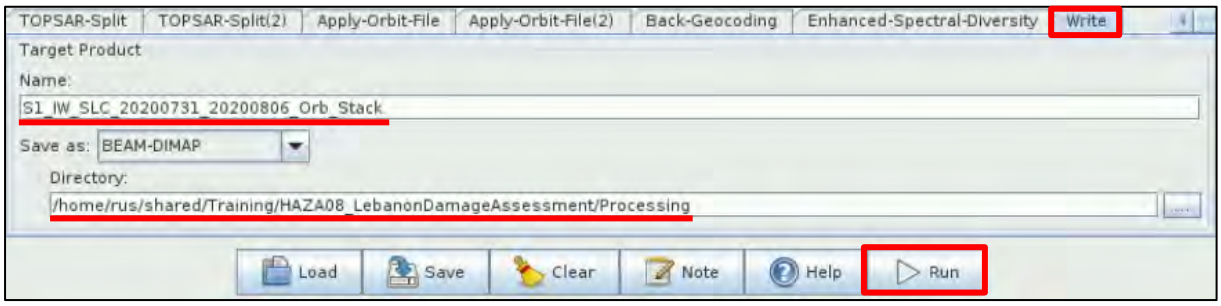
In the **Back-Geocoding** tab set again: **Digital Elevation Model:** SRTM 1Sec HGT (Auto Download), **select** the "**Output Deramp and Demod Phase**" option as well and leave the rest parameters as by default.



In the **Enhanced-Spectral-Diversity** tab keep all the default parameters.

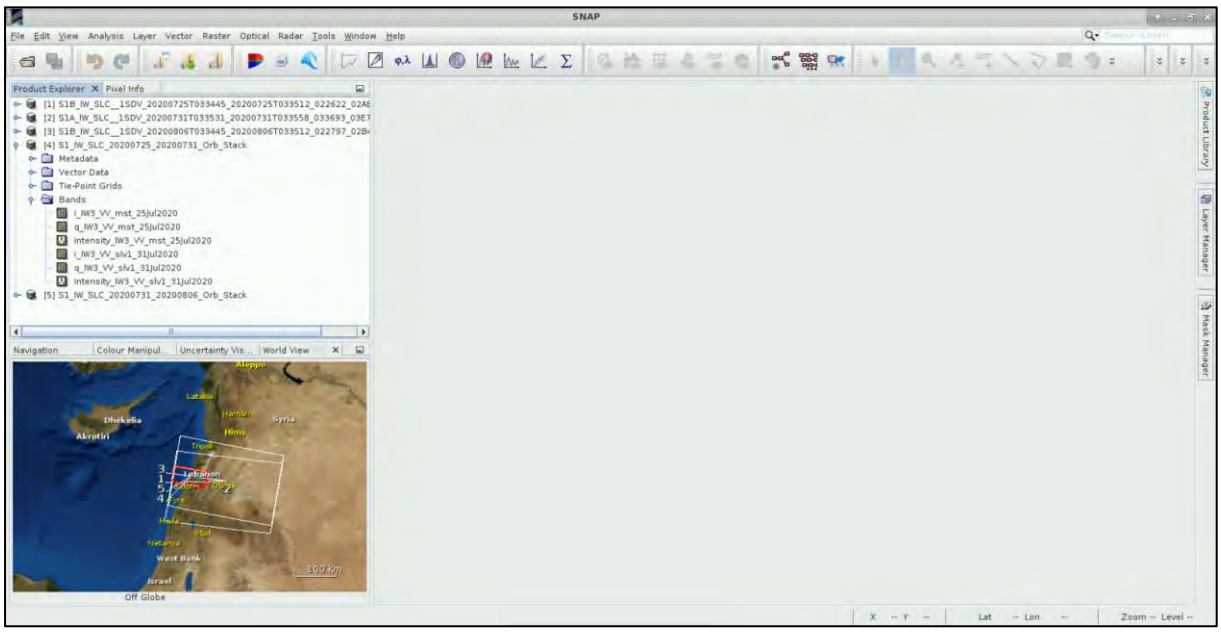


In the **Write** tab set the following:
Name: S1_IW_SLC_20200731_20200806_Orb_Stack
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



Click **Run**. Once the processing is completed, the coregistered product will appear at the **Product Explorer** Window as well.

If we now expand the **Bands** folder of both the coregistered products, we will see that they contain the information of both the images used.

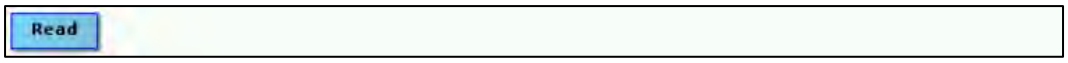


5.4 Sentinel-1 Processing – Part 2

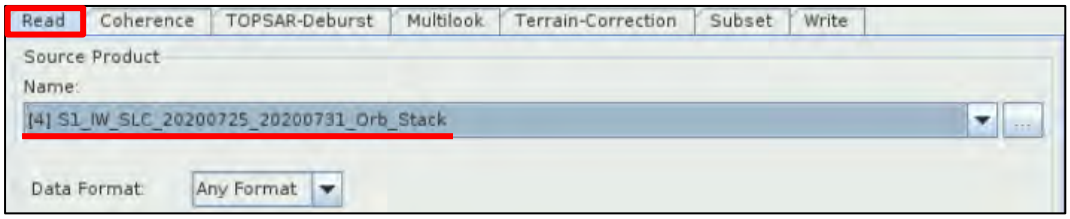
In this part of the Sentinel-1 processing, we will create another graph where we will apply the necessary steps on the two coregistered products, in order to have them ready to extract the information showing the damage caused at the area due to the explosion. First, we will perform it for the coregistered product with the images before the event, and then for the coregistered product with the one image before and the one after the event.

5.4.1 Graph Builder

Let's go again to **Tools → GraphBuilder**, right-click on the **Write** operator and **Delete** it. This time we can set the parameters in each tab, along with the creation of the corresponding operator.

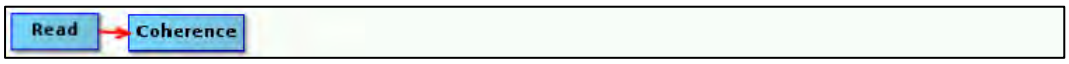


In the **Read** tab, as Source Product, select the product with Name:
S1_IW_SLC_20200725_20200731_Orb_Stack

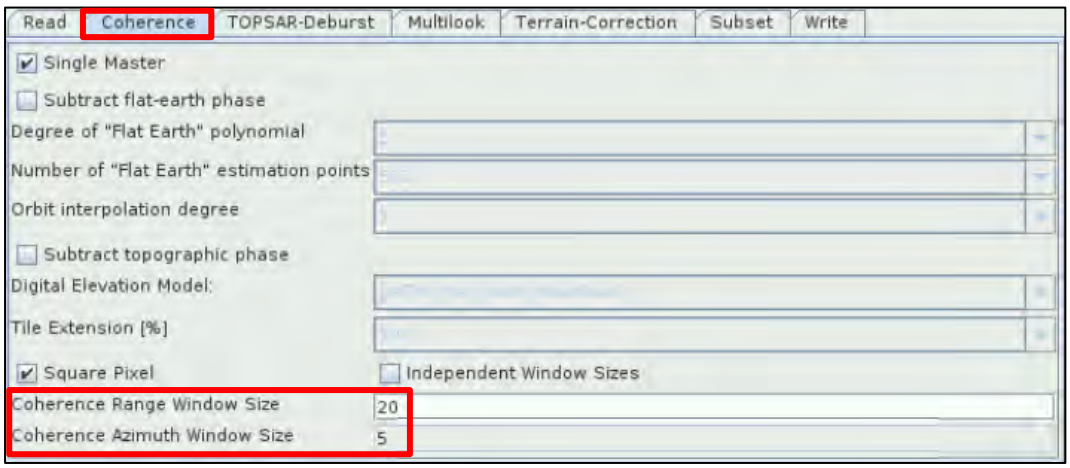


5.4.2 Coherence Estimation

Since we are having in the coregistered product the *Intensity* bands of both products, we will use the **Coherence** operator, to estimate how well "correlated" the pixels between the master and slave images used, are. Right-click and go to **Add → Radar → Interferometric → Products → Coherence**. Connect the **Read** operator to it.

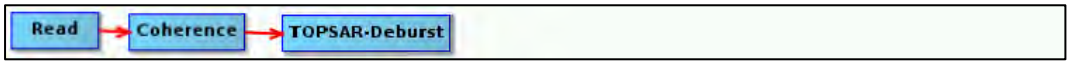


In the **Coherence** tab, set as **Coherence Range Window Size**: 20 and the **Coherence Azimuth Window Size** will automatically turn to 5.

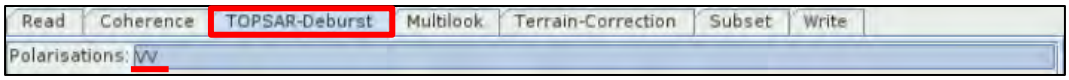


5.4.3 TOPS Deburst

Now we will remove the "black space" between the two bursts (See NOTE 5). To add the **TOPSAR-Deburst** operator right-click and go to **Add → Radar → Sentinel-1 TOPS → TOPSAR-Deburst**. Connect the **Coherence** operator to it.



In the **TOPSAR-Deburst** tab keep the default settings (Polarizations: **VV**).

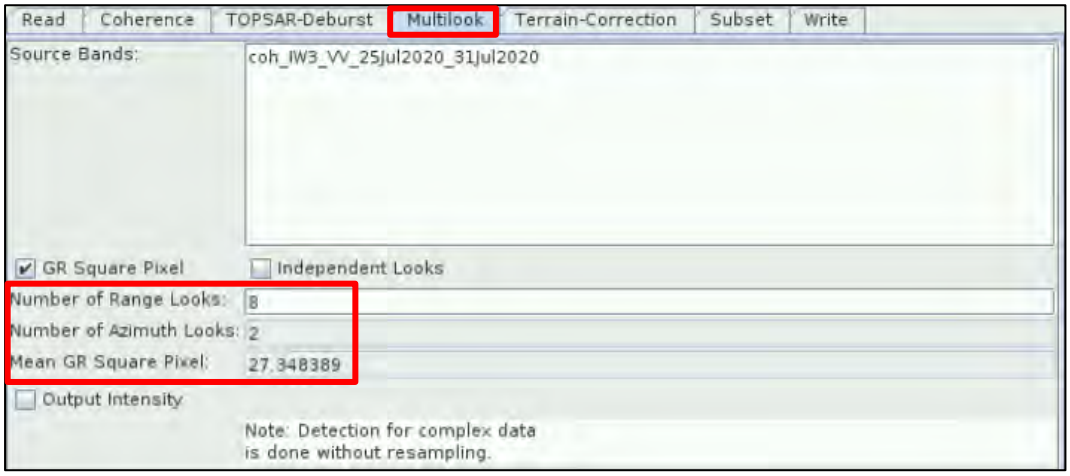


NOTE 5: There is overlapping information in every burst with its neighbouring ones, both in range and azimuth direction in order to provide contiguous coverage of the ground. Until now each burst has been processed as a separate SLC image We will merge the bursts (in azimuth direction) and preserve the phase information as well. For the overlapping region in range, merging is done between subswaths.

5.4.4 Mulitlooking

By applying this operator, we will reduce the inherent speckle noise that originally appears to the SAR images and we will obtain square pixels. To add the **Multilook** operator right-click and go to **Add → Radar → SAR Utilities → Multilook**. Connect the **TOPSAR-Deburst** operator to it.

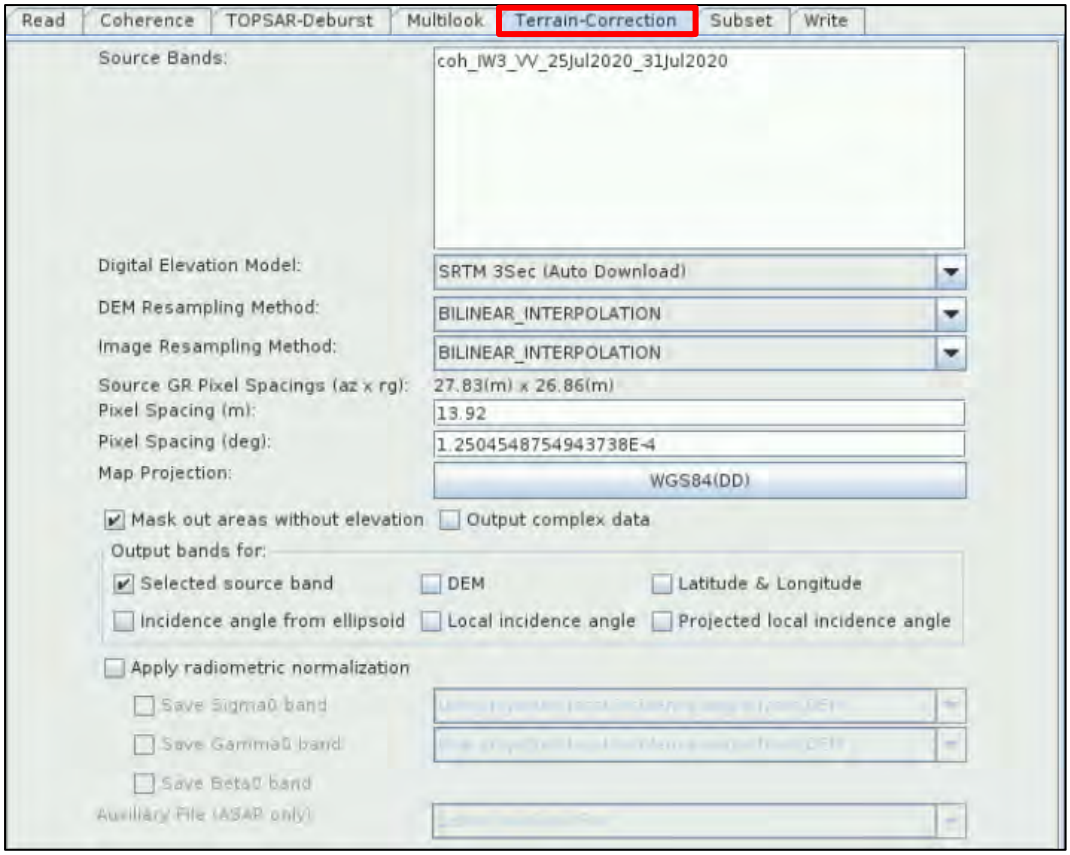
In the **Multilook** tab keep the "**GR Square Pixel**" option selected and set **Number of Range Looks**: 8. The **Number of Azimuth Looks** will change to 2 and the **Mean GR Square Pixel** to 27.348389.



5.4.5 Geocoding – Terrain Correction

We will apply the **Terrain Correction** operator, to convert the RADAR coordinates into geographic. To add the **Terrain-Correction** operator, right-click and go to **Radar → Geometric → Terrain Correction → Terrain-Correction**.

In the **Processing Parameters** tab keep the default parameters.

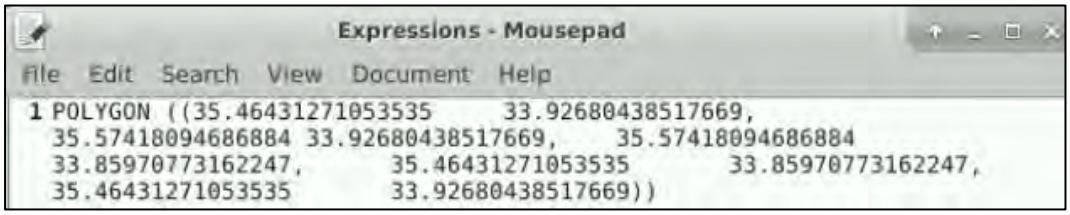


5.4.6 Subset

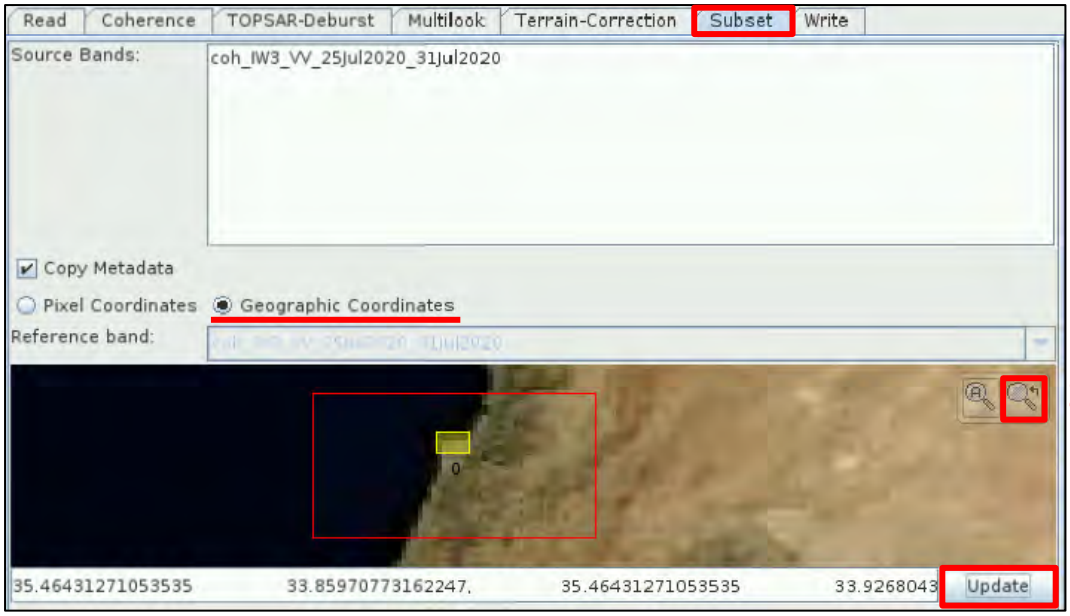
We will now create a Subset of the product, since we do not need the whole extent of it. You can set a different area according to your needs, or even skip the Subset step and keep the whole extent. To add the **Subset** operator, go to **Add → Raster → Geometric → Subset**.

At the **Subset** tab, select the **Geographic Coordinates** option. Copy the WKT (well know text) shown below from the */shared/Training/HAZA08_LebanonDamageAssessment/AuxData/Expressions* folder and paste it to the text window below the map.

```
POLYGON    ((35.46431271053535    33.92680438517669,    35.57418094686884
33.92680438517669, 35.57418094686884 33.85970773162247, 35.46431271053535
33.85970773162247, 35.46431271053535 33.92680438517669))
```



Click **Update** and then click the **Zoom-in** icon  to see your subset on the map.

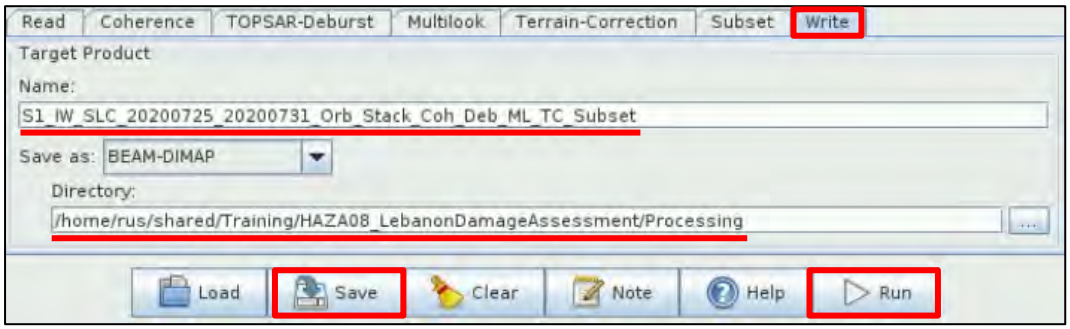


Zoom in

5.4.7 Write – create the output

To create the output of this processing, we will add the **Write** operator. Right-click and go to **Add → Input-Output → Write**. Connect the **Subset** operator to it.

In the **Write** tab set the following:
Name: S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



Click on the 

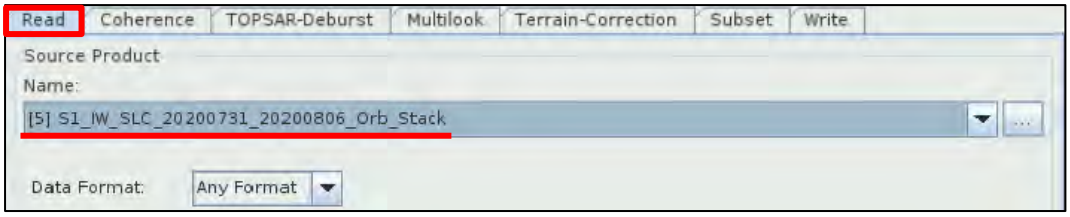
icon to save the graph for future use. Go to the: */shared/Training/HAZA08_LebanonDamageAssessment/AuxData* folder and save it with the name: **Graph_S1_part2**.

Click **Run**. Once the processing is completed, the product will appear at the **Product Explorer** Window.

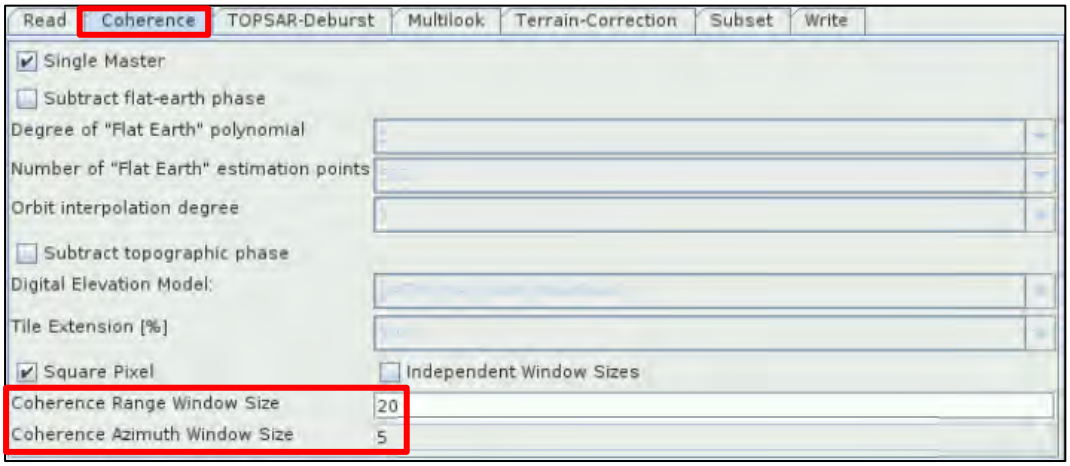
5.4.8 Repeat chapters 5.4.2 to 5.4.7

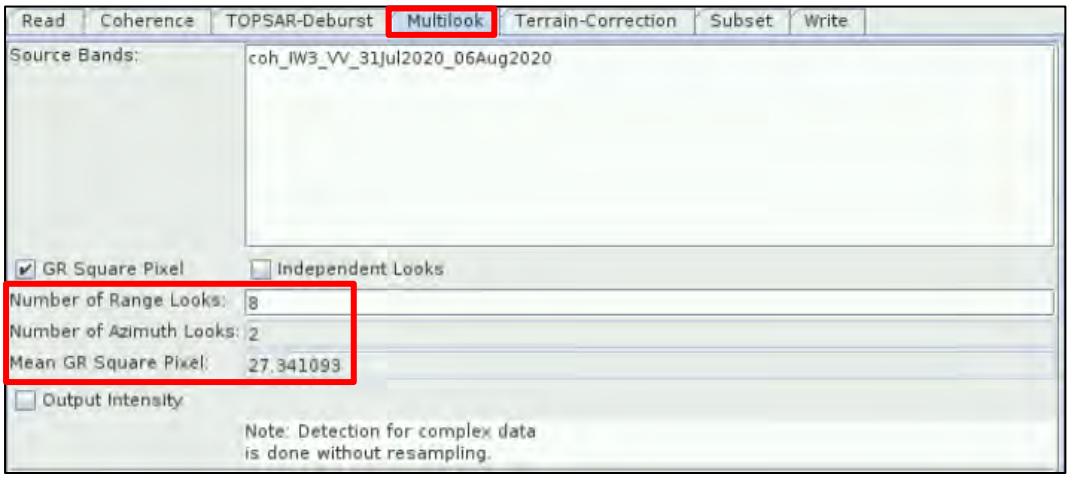
We will now keep the same graph we have built, opened, and we will go again tab by tab, to set the new parameters in each one, so that we will extract the information showing the damage caused at the area due to the explosion, of the second coregistered product (with the one image before and the one after the event). Let's go all the way up to the chapters 5.4.1 to 5.4.7.

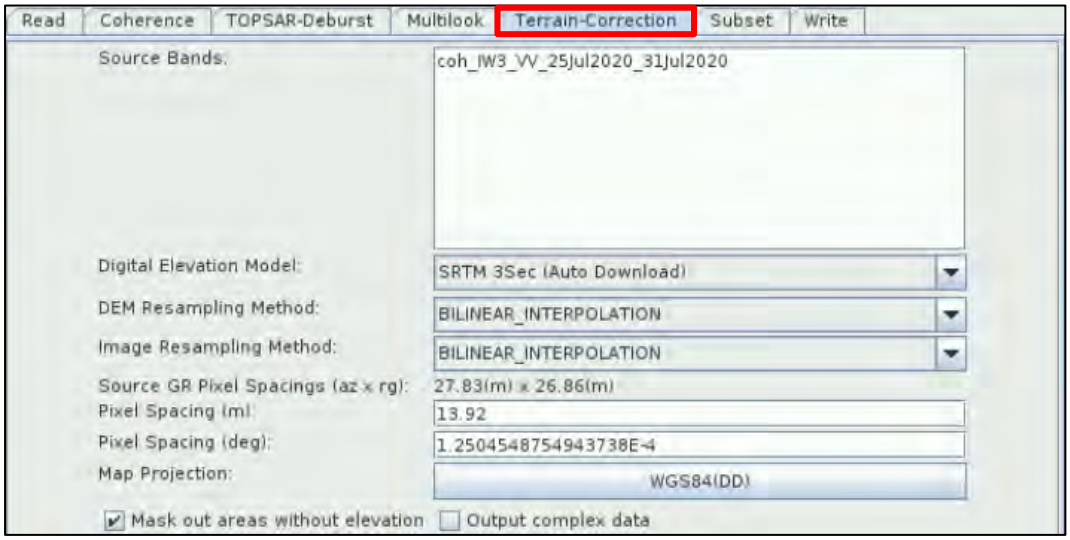
In the **Read** tab, as Source Product, select the product with Name:
S1_IW_SLC_20200731_20200806_Orb_Stack



In the **Coherence**, **TOPSAR-Deburst**, **Multilook** and **Terrain-Correction** tabs, keep the same parameters as before. Check each one to make sure they have not been modified.

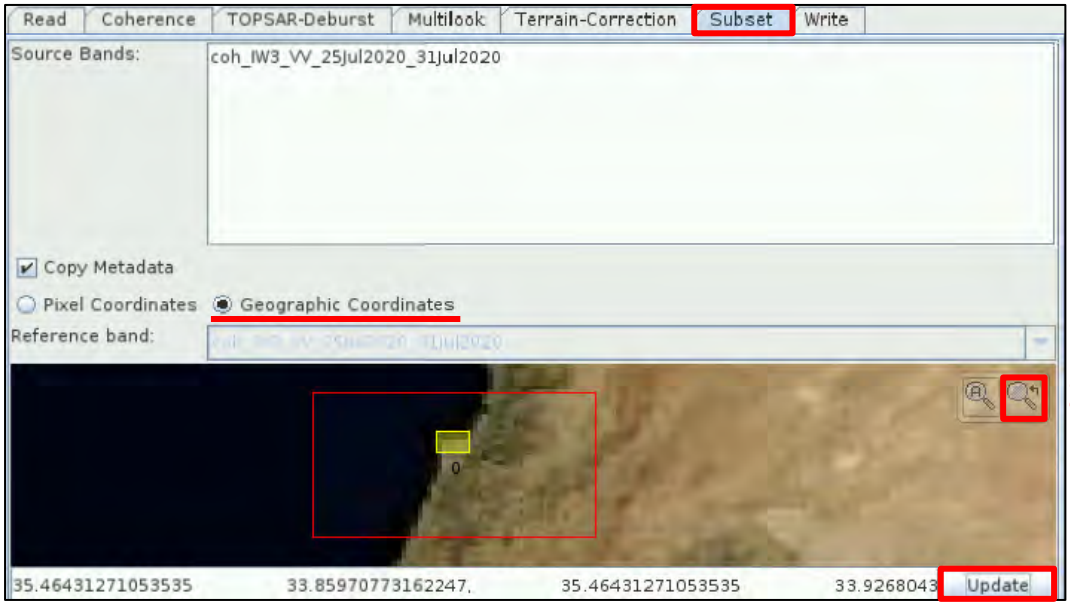






In the **Subset** tab, keep the same parameters as before. Copy again the WKT (well know text) from the */shared/Training/HAZA08_LebanonDamageAssessment/AuxData/Expressions* folder and paste it to the text window below the map.

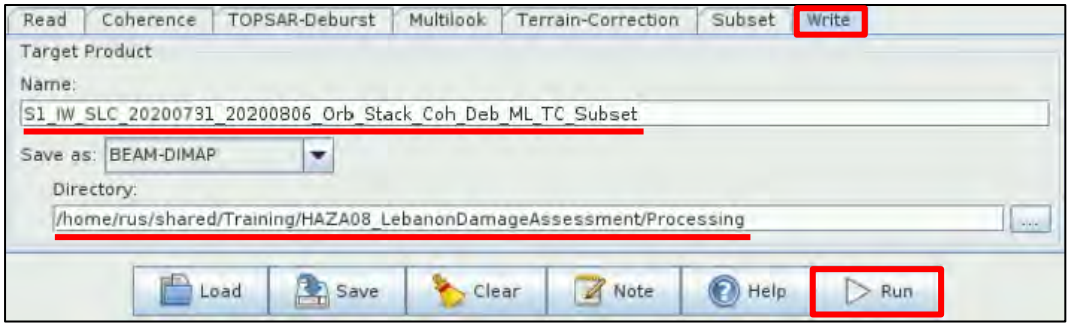
Click **Update** and then click the **Zoom-in** icon to see your subset on the map.



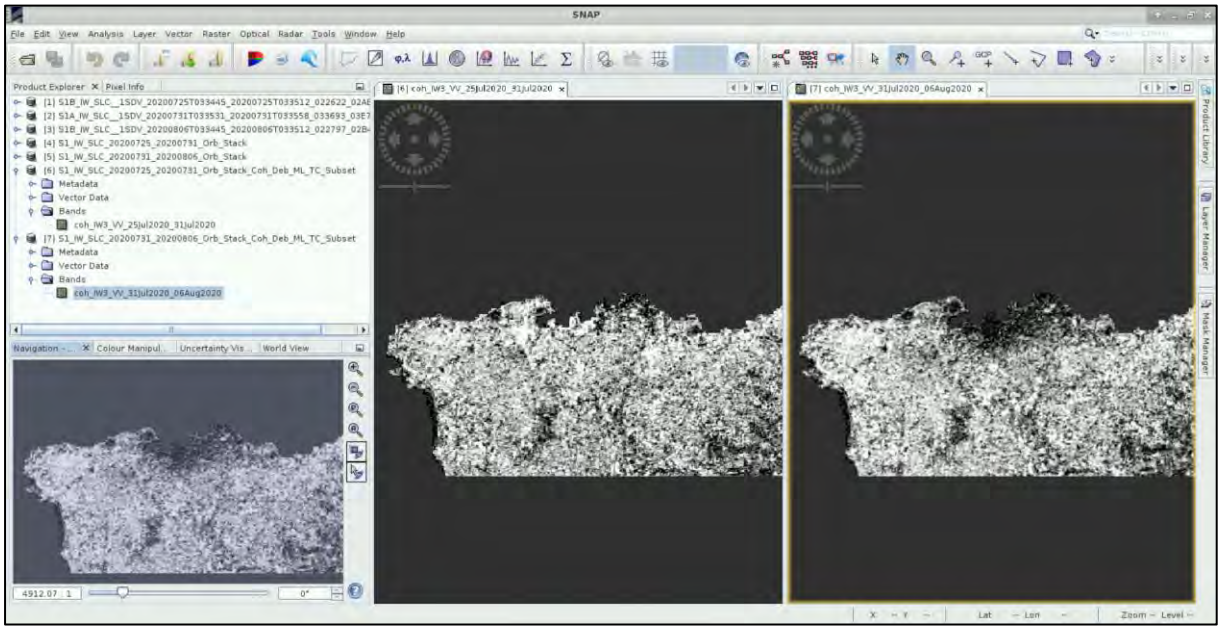
In the **Write** tab set the following:

Name: S1_IW_SLC_20200731_20200806_Orb_Stack_Coh_Deb_ML_TC_Subset

Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



Click **Run**. Once the processing is completed, the product will appear at the **Product Explorer** Window.



5.5 Sentinel-1 Processing – Part 3

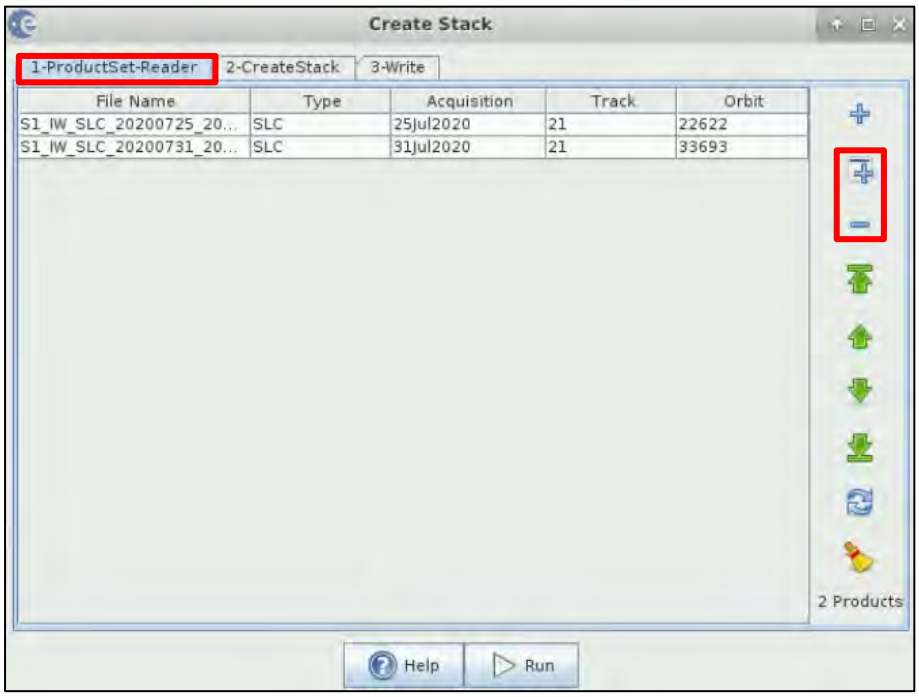
Now that we have created both final products that include the bands with the estimated coherence, we need to put them into one, in order to be allowed to apply the Change Detection operator. To do so, we will use the Create Stack operator.

5.5.1 Create Stack

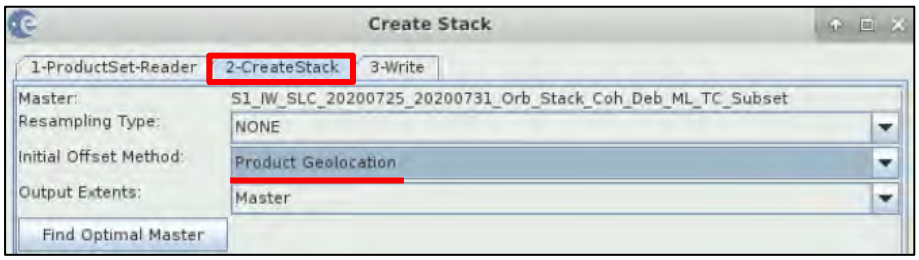
Go to **Radar → Coregistration → Stack Tools → Create Stack**.

In the **1-ProductSet-Reader** tab, click on **Add Opened**, and all the products that are opened in the **Product Explorer** Window will be loaded. We need to keep only the last two. Select all the previous ones, and click on the icon to remove them.

Once there are only the 2 products that we want to stack, click on the Refresh icon. The relative information will appear at the rest fields as shown below.

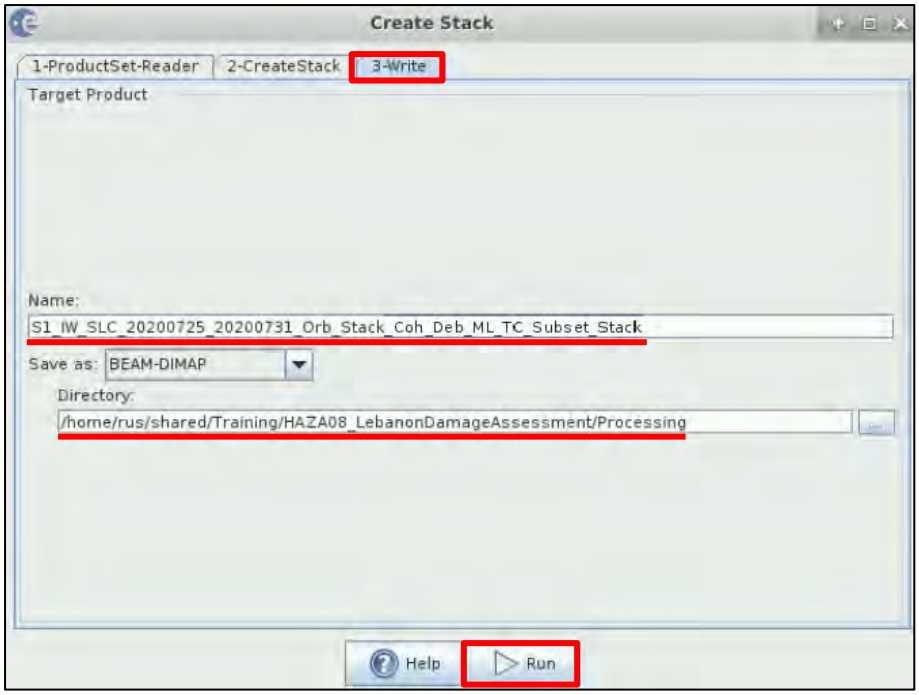


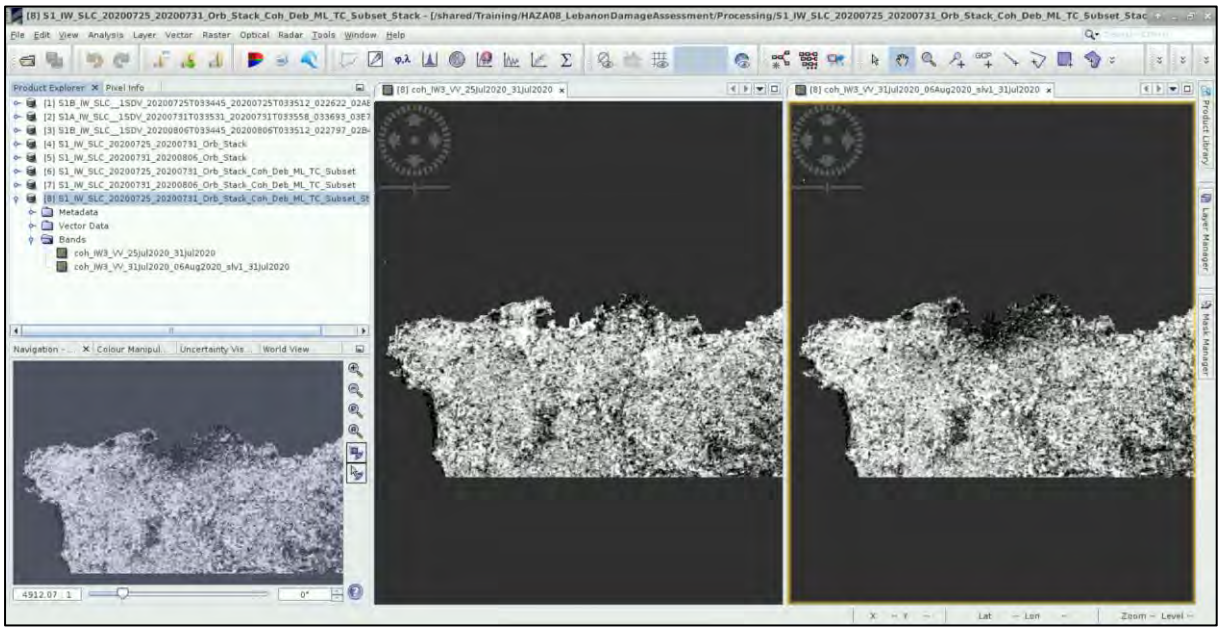
In the **2-CreateStack** tab, set as **Initial Offset Method**: Product Geolocation, and keep the rest parameters as by default.



In the **Write** tab set the following:
Name: S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*

Click **Run**. The Stack product that will contain the coherence bands of both final products, will appear at the **Product Explorer** Window.





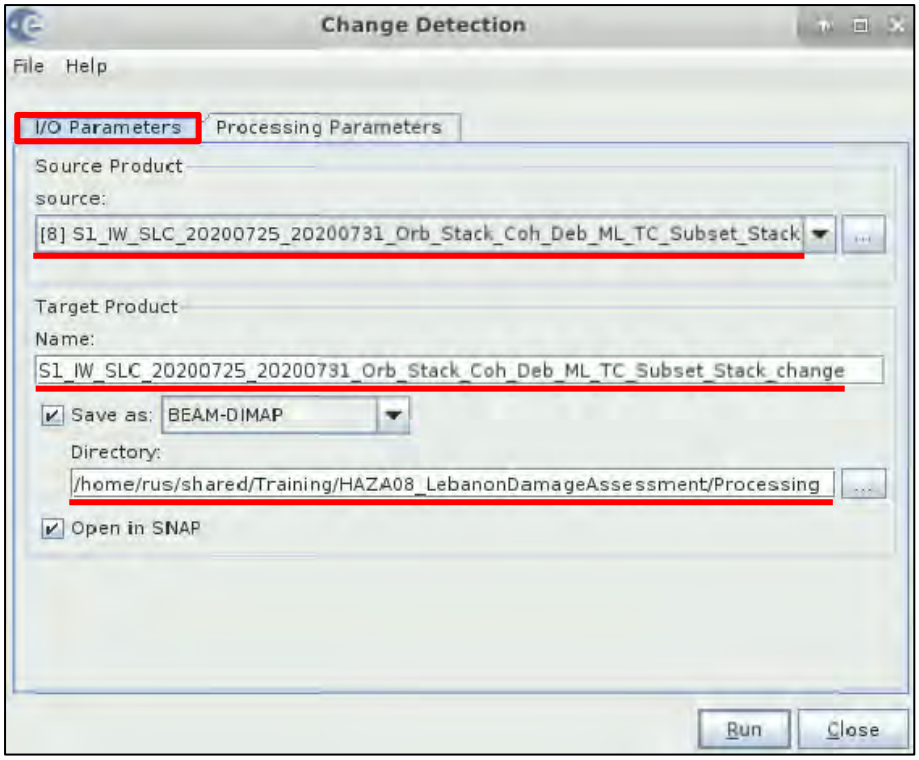
5.5.2 Change Detection

This is the final step, where we will detect the changes between the two coherence images, and the result of it will show us the damage caused due to the explosion.

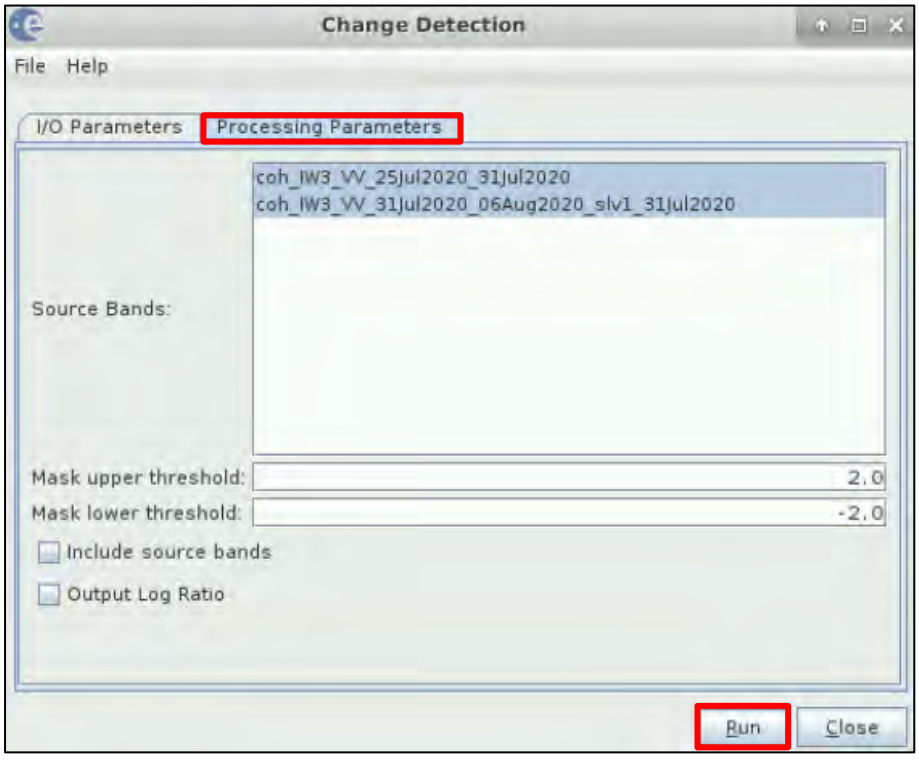
Go to **Radar → SAR Applications → Change Detection**.

In the **I/O Parameters** tab set the following:

Source: S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack
Name: S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*

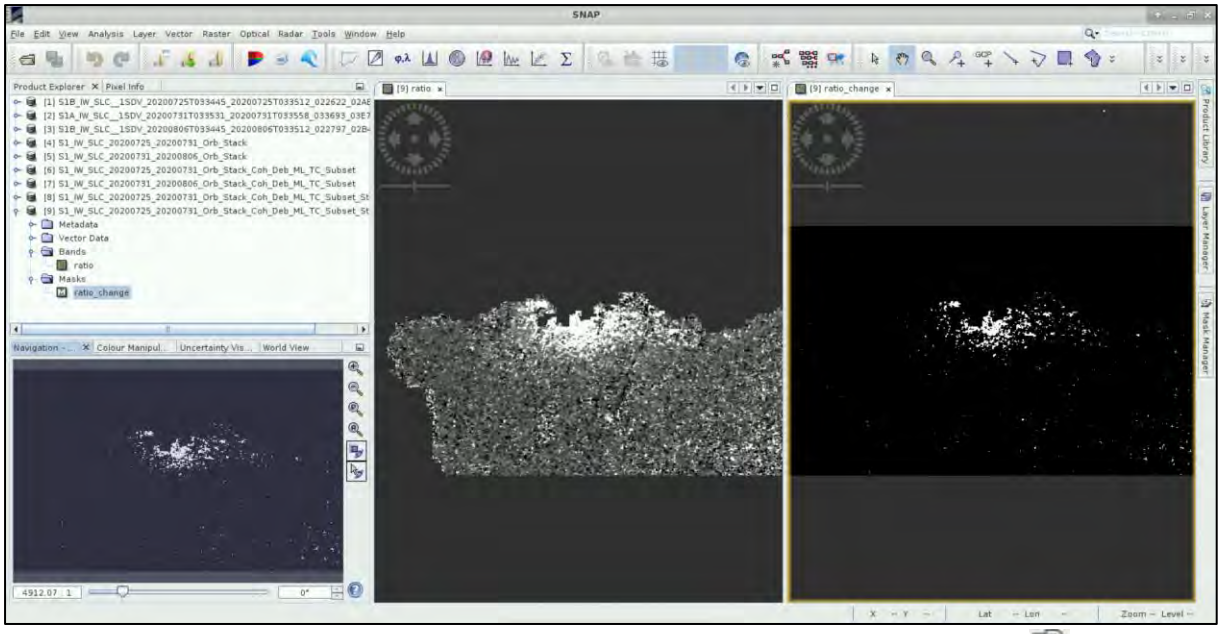


In the **Processing Parameters** tab keep the default parameters and click **Run**.

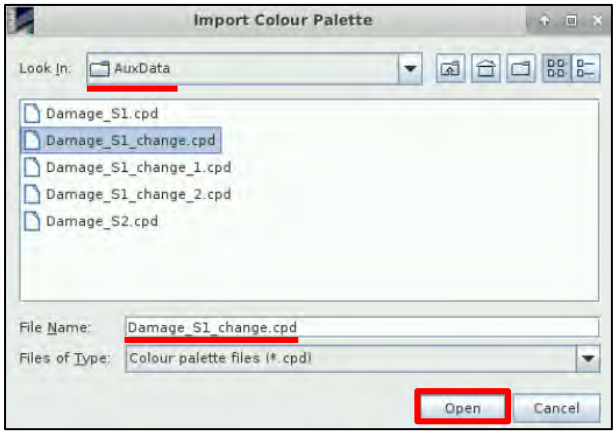


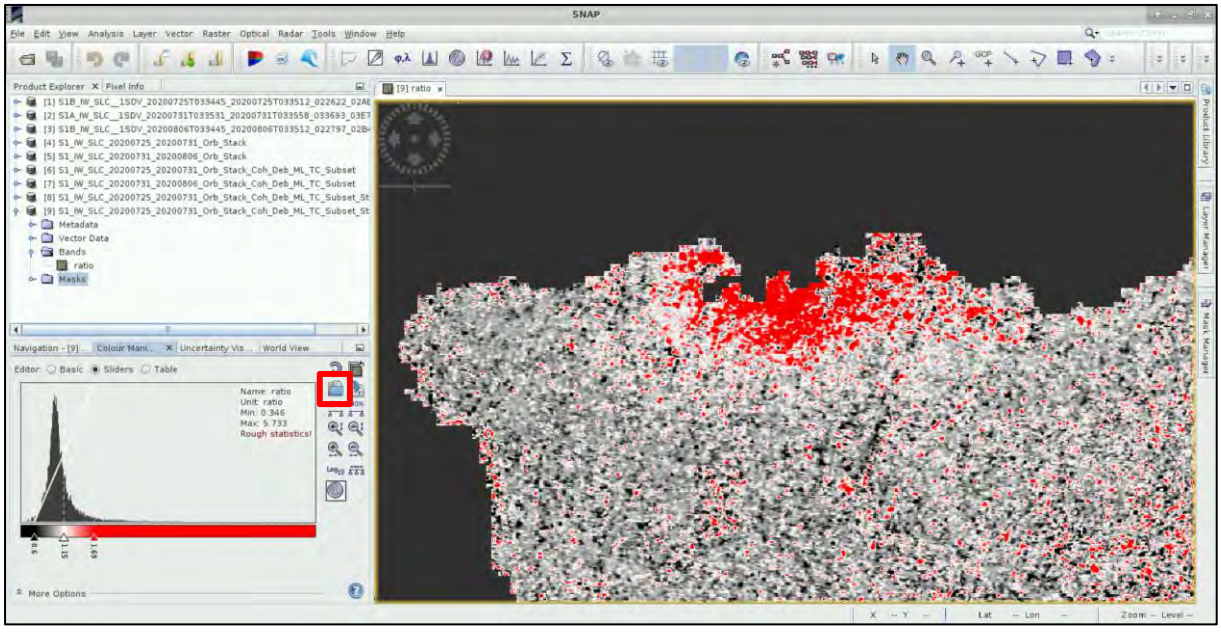
The product with the change detection result will appear at the **Product Explorer** Window. Expand the *Bands* folder and double click on the ***ratio*** band to open it at the **View** Window. You can also expand the *Masks* folder and open the ***ratio_change*** band.

We will work with the ***ratio*** band, but you can apply the following steps to the ***ratio_change*** band if you wish as well.

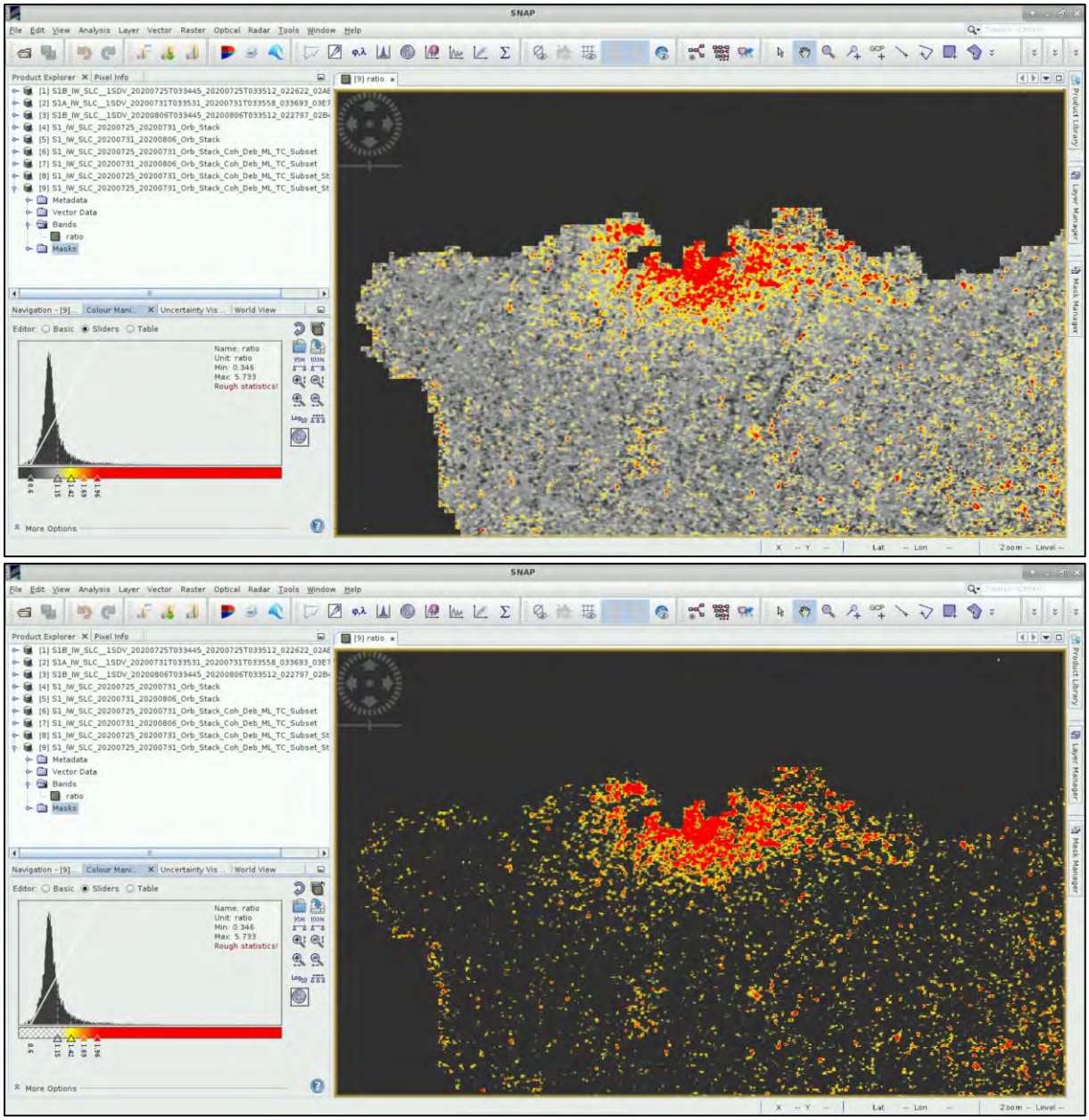


Go to the Colour Manipulation tab on the left and click on the **Import Colour Palette** icon. Then, navigate to the */shared/Training/HAZA08_LebanonDamageAssessment/AuxData* folder, select the **Damage_S1_change.cpd** and click **Open**. At the window message that appears below, click **No**.

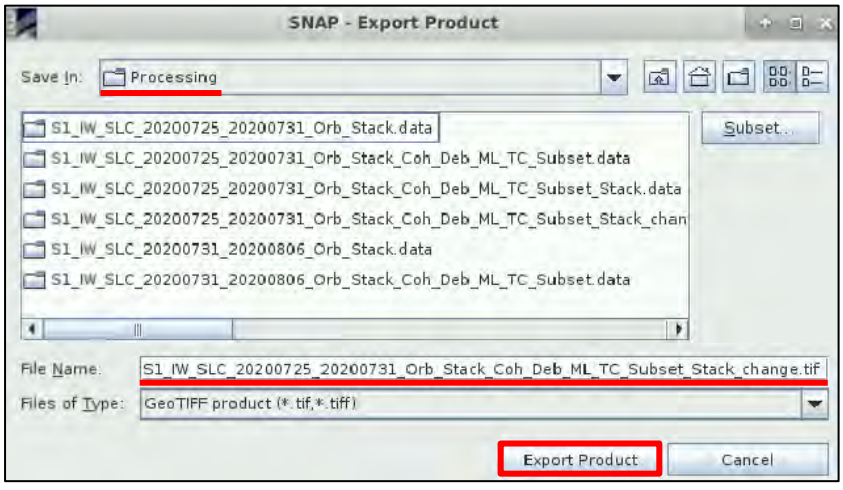




Repeat the last step. Open the palettes **Damage_S1_change_1.cpd** and **Damage_S1_change_2.cpd.**



5.5.3 Export Sentinel-1 product



Select the *S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change* product and go to **File → Export → GeoTIFF**.

The **File Name** will be set to S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change.tif.

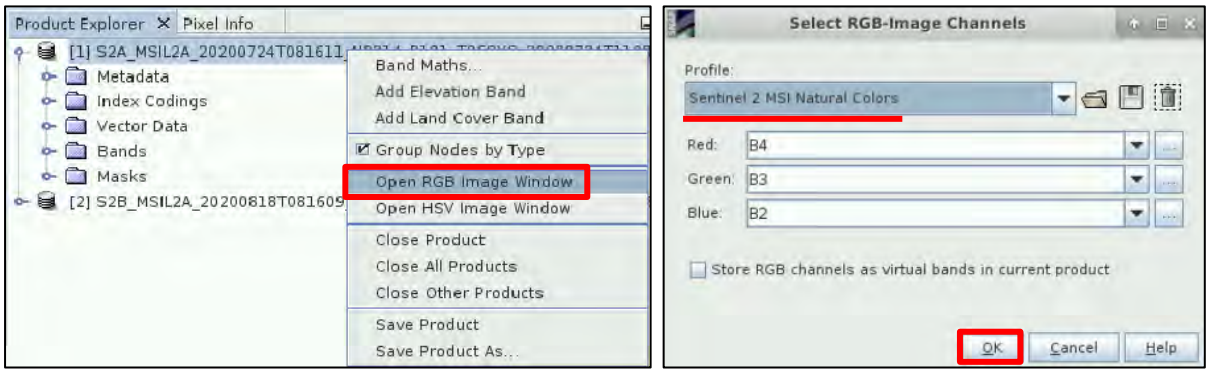
At the **Save in** field, set the */shared/Training/HAZA08_LebanonDamageAssessment/Processing* path. Click **Export Product**.

5.6 Sentinel-2 Processing – Part 1

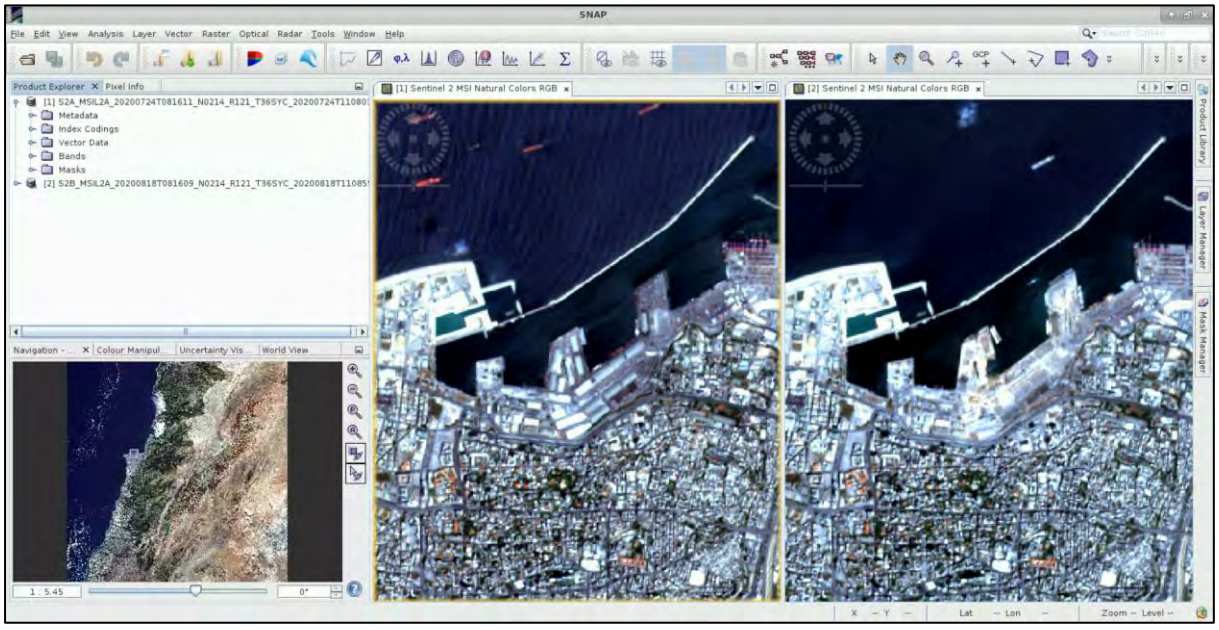
Close SNAP and reopen it, to load the Sentinel-2 products this time. First load the product before the event, *S2A_MSIL2A_20200724T081611_N0214_R121_T36SYC_20200724T110803* and then the one after the event, *S2B_MSIL2A_20200818T081609_N0214_R121_T36SYC_20200818T110855*.

5.6.1 Create RGB image

Right click on the first product and select **Open RGB Image Window**. At the Profile, select: **Sentinel 2 MSI Natural Colours**. The B4, B3 and B2 bands will be selected. Click **OK**. Right click at the second product as well and open another RGB image.

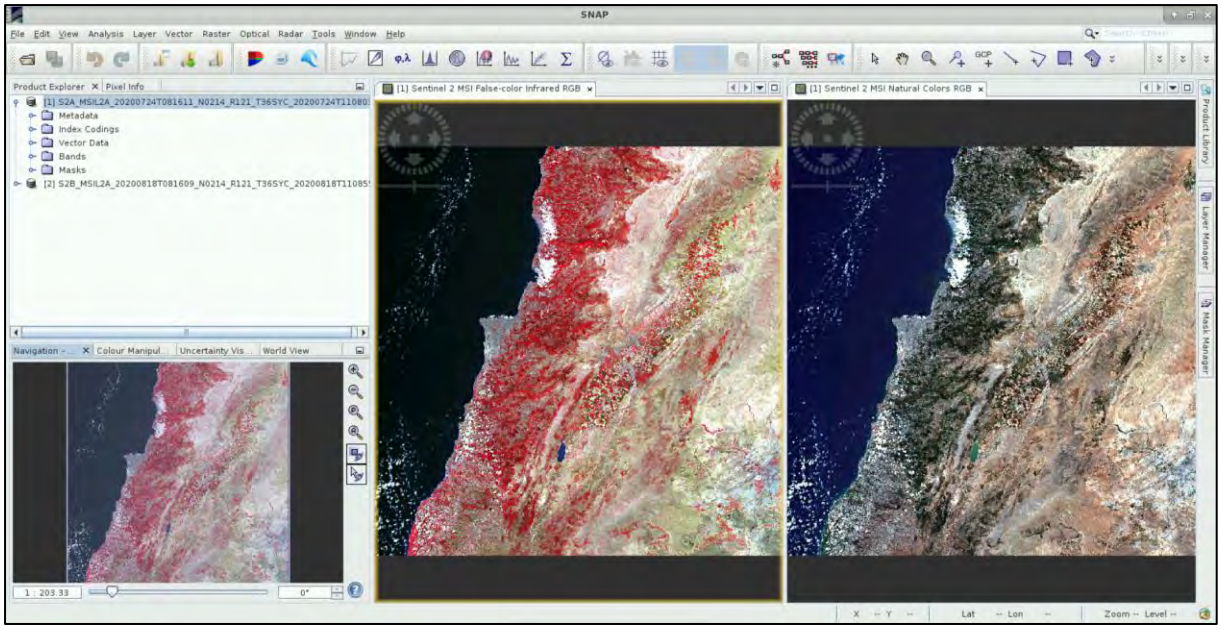


Go to **Window → Tile Horizontally** to see the two RGB images created side by side. If we zoom in over the area of the port, we can clearly see the damages on the right one.



We can close the second image, and right click again on the first one to create another RGB image. This time, at the Profile select: **Sentinel-2 MSI False-Colour Infrared**. The B8, B4 and B3 bands will be selected**.** Click **OK.**

We see the different result B8 (NIR) is giving us and this is the band we will use to detect the changes over the area once we complete all the pre-processing steps.

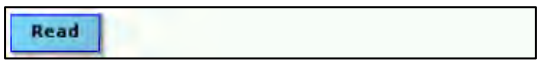


5.6.2 Graph Builder

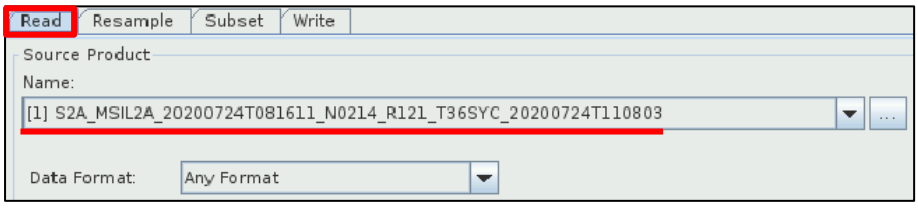
We will create again a Graph, where we will insert all the necessary operators, in order to prepare our data for the damage assessment. First, we will apply it for the product before the event and then we will repeat it for the product after the event. Go to **Tools** → **GraphBuilder**. Right-click on the **Write** operator and **Delete** it.

5.6.3 Read inputs

We will set the parameters in each tab along with the operators.



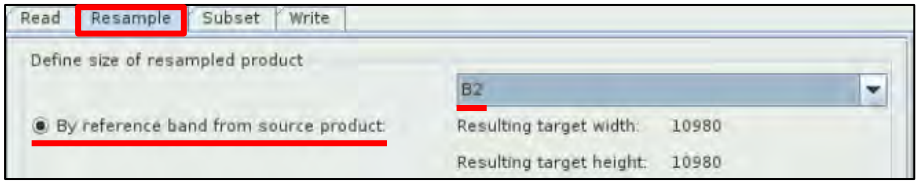
In the **Read** tab, as Source Product, select the product with Name:
S2A_MSIL2A_20200724T081611_N0214_R121_T36SYC_20200724T110803



5.6.4 Resample

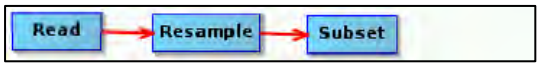
We then need to resample all the Bands so that they have a common resolution, otherwise we cannot proceed with the next steps. To add the **Resample** operator, right-click and go to **Add** → **Raster** → **Geometric** → **Resample**. Connect the **Read** operator to it.

In the **Resample** tab, select under the "Define size of resampled product" select the option: **By reference band from source product** and then select **B2**. This way we will resample all the bands in 20m. If you want to resample them in e.g. 10m, you can select the B1 band.



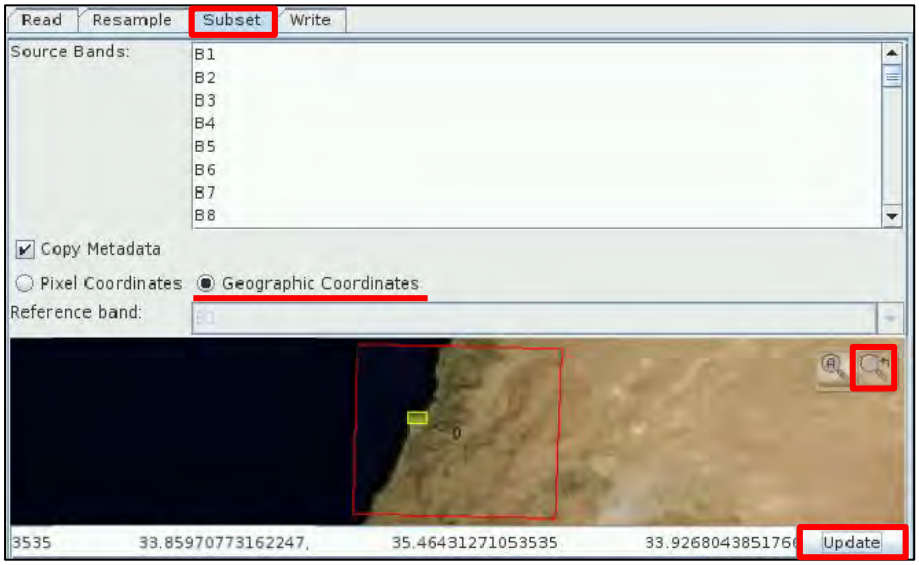
5.6.5 Subset

We will now create a Subset of the first product, as we did for the Sentinel-1 product before. To add the **Subset** operator, go to **Add → Raster → Geometric → Subset**.



At the **Subset** tab, select the **Geographic Coordinates** option and copy the WKT (well know text) from the */shared/Training/HAZA08_LebanonDamageAssessment/AuxData/Expressions* folder as mentioned before and paste it to the text window below the map.

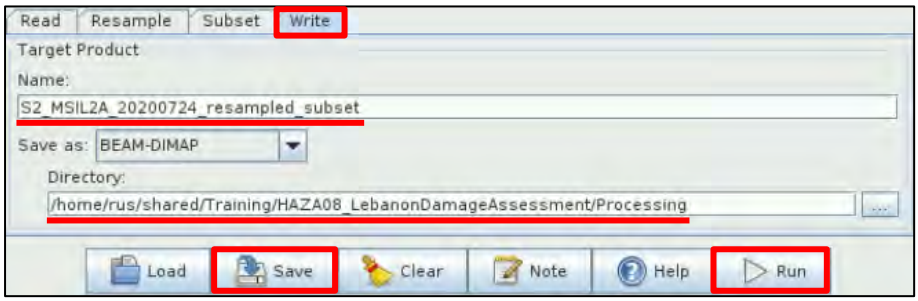
Click **Update** and then click the **Zoom-in** icon to see your subset on the map.



5.6.6 Write – create the outputs

To create the output of this processing, we will add the **Write** operator. Right-click and go to **Add → Input-Output → Write**. Connect the **Subset** operator to it.

In the **Write** tab set the following:
Name: S2_MSIL2A_20200724_resampled_subset
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



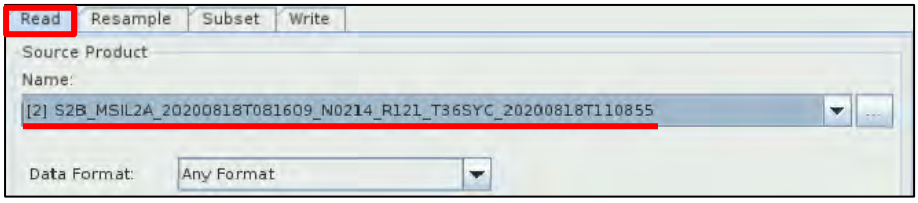
Click on the Save icon to save the graph for future use. Go to the: */shared/Training/HAZA08_LebanonDamageAssessment/AuxData* folder and save it with the name: **Graph_S2**.

Click **Run**. Once the processing is completed, the product will appear at the **Product Explorer** Window.

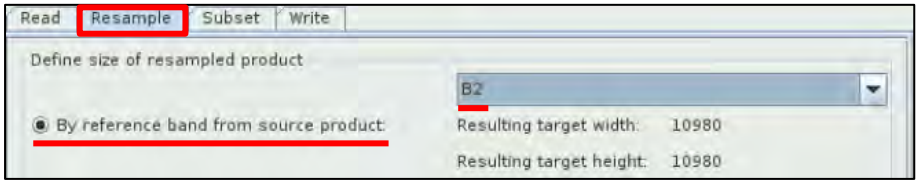
5.6.7 Repeat chapters 5.6.3 to 5.6.6

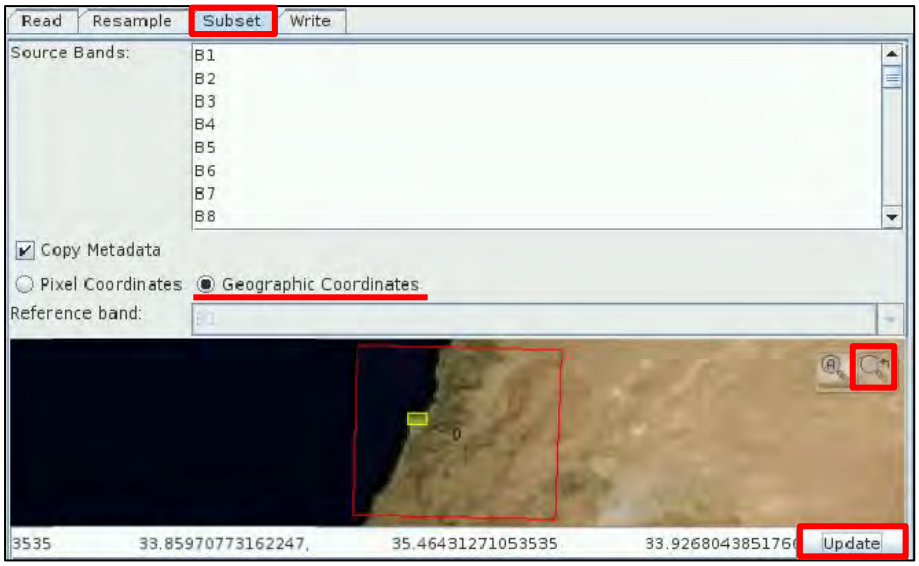
Now let's repeat the same steps for the second product.

In the **Read** tab, as Source Product, select the product with Name:
S2B_MSIL2A_20200818T081609_N0214_R121_T36SYC_20200818T110855



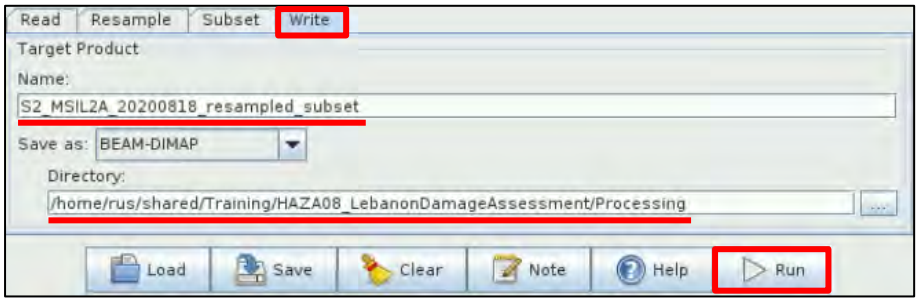
In the **Resample** and **Subset** tabs, keep the same parameters as before. Check each one to make sure they have not been modified.





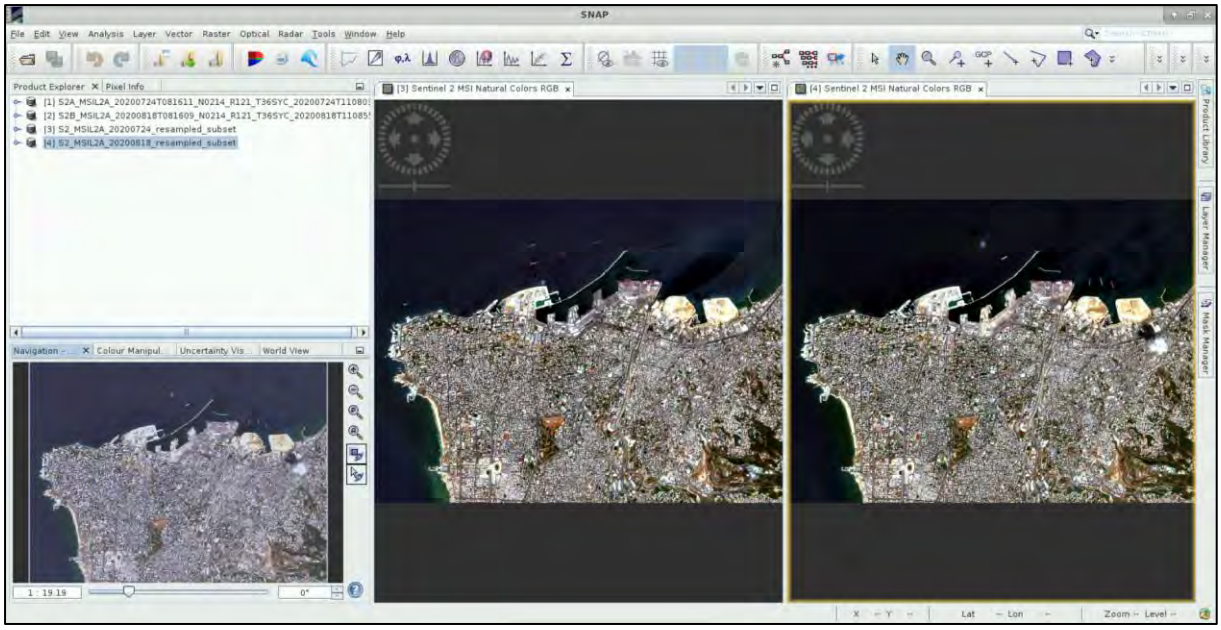
Zoom in

In the **Write** tab set the following:
Name: S2_MSIL2A_20200818_resampled_subset
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



Click **Run**. Once the processing is completed, the product will appear at the **Product Explorer** Window.

You can open both Subset products at the **View** Window, to see their extent.



5.7 *Sentinel-2 Processing – Part 2*

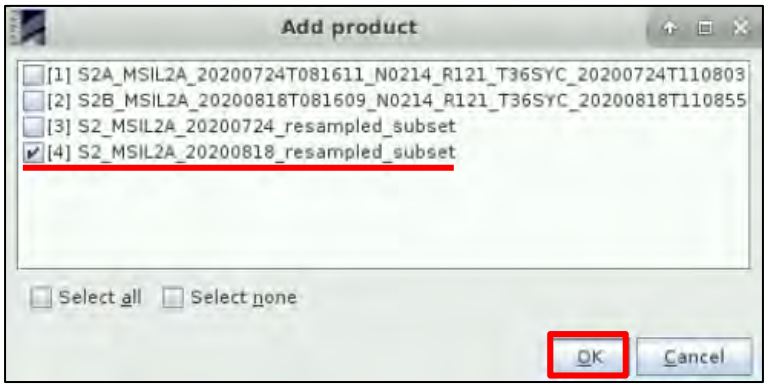
Once we have both products subset, we need to put them in one, as we did before with the Sentinel-1 products. For sentinel-2 products, we will use the **Collocation** operator.

5.7.1 Collocation

Go to **Raster → Geometric Operations → Collocation.**

As "Master" product, select the **S2_MSIL2A_20200724_resampled_subset**

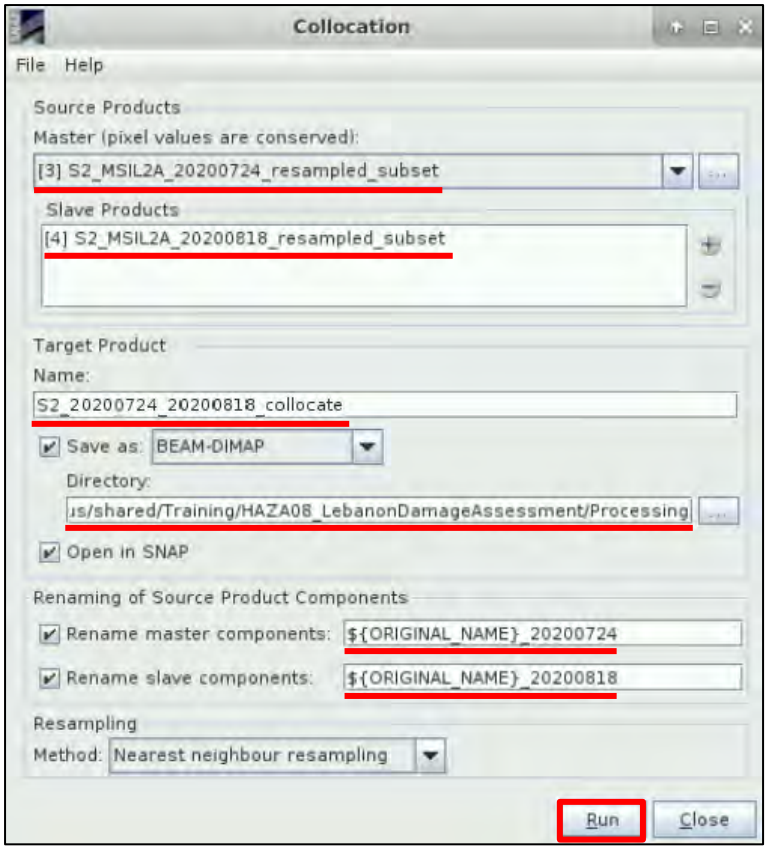
As "Slave" Product, click on the *Add product(s)* and select the **S2_MSIL2A_20200724_resampled_subset** and click **OK**.



As "Name", set **S2_20200724_20200818_collocate**

Under the "Renaming of Source Product Components", at "Rename master components" set: **${ORIGINAL_NAME}_20200724** and at "Rename slave components" set: **${ORIGINAL_NAME}_20200818**.

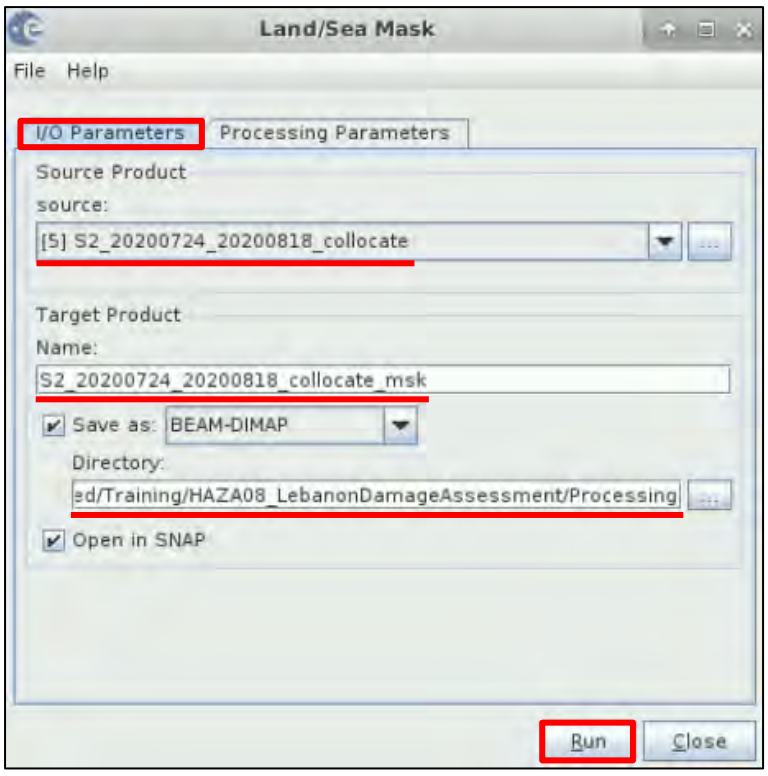
Click **Run** and once the processing is completed, the collocated product will appear in the **Product Explorer** Window.



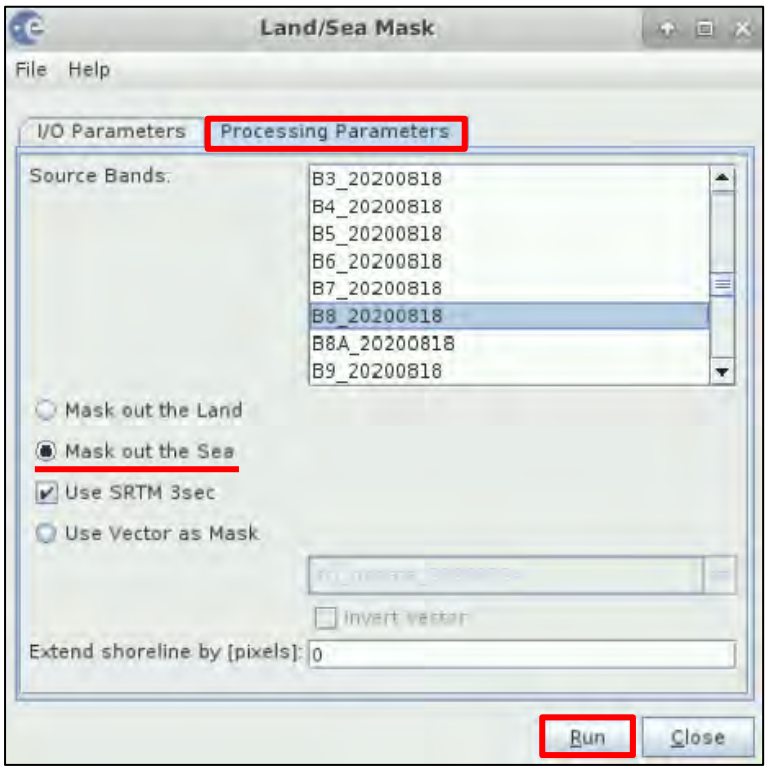
5.7.2 Sea Mask

We want to remove the pixels that correspond to the Sea. Go to **Raster → Masks → Land/Sea Mask**.

In the I/O Parameters tab set as "Source Product": **S2_20200724_20200818_collocate**, as "Name": **S2_20200724_20200818_collocate_msk** and as directory */shared/Training/HAZA08_LebanonDamageAssessment/Processing*

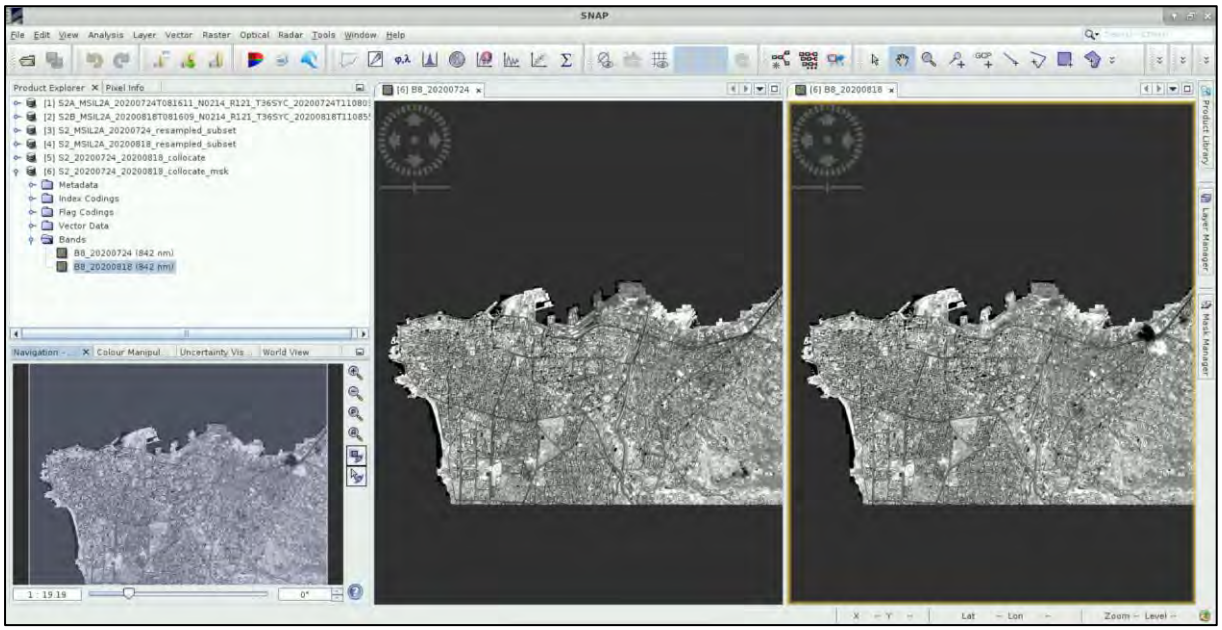


In the **Processing Parameters** tab, at the "Source Bands" keep the **Ctrl** pressed and select only the **B8_20200724** and **B8_20200818** bands. Check the **Mask out the Sea** option and click **Run**.



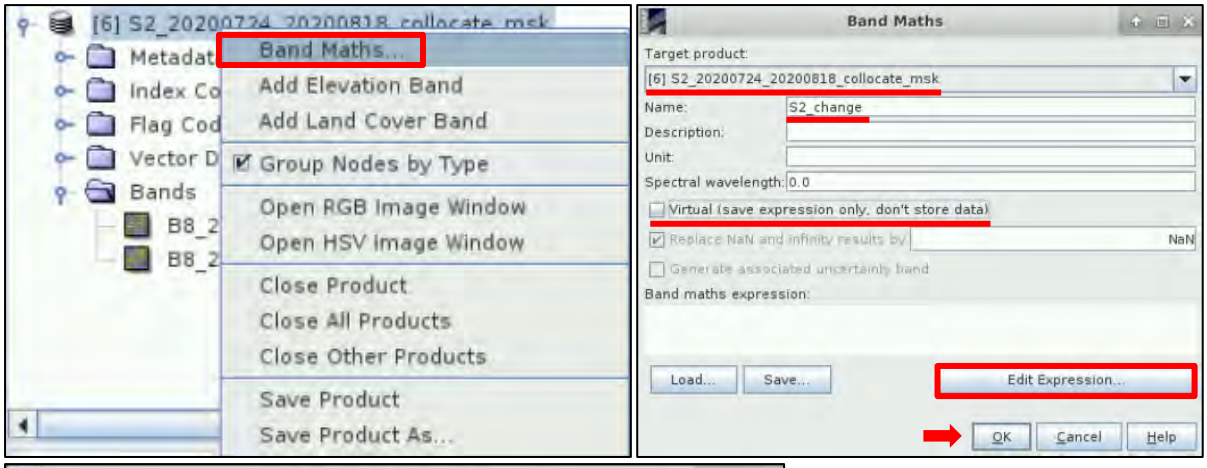
Select:
B8_20200724
B8_20200818

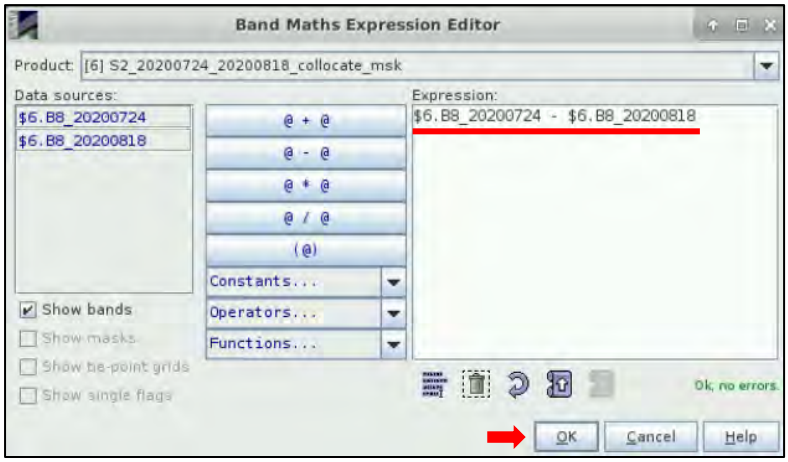
If we open the B8 bands of the masked, collocated product, we will see that the sea has been removed.

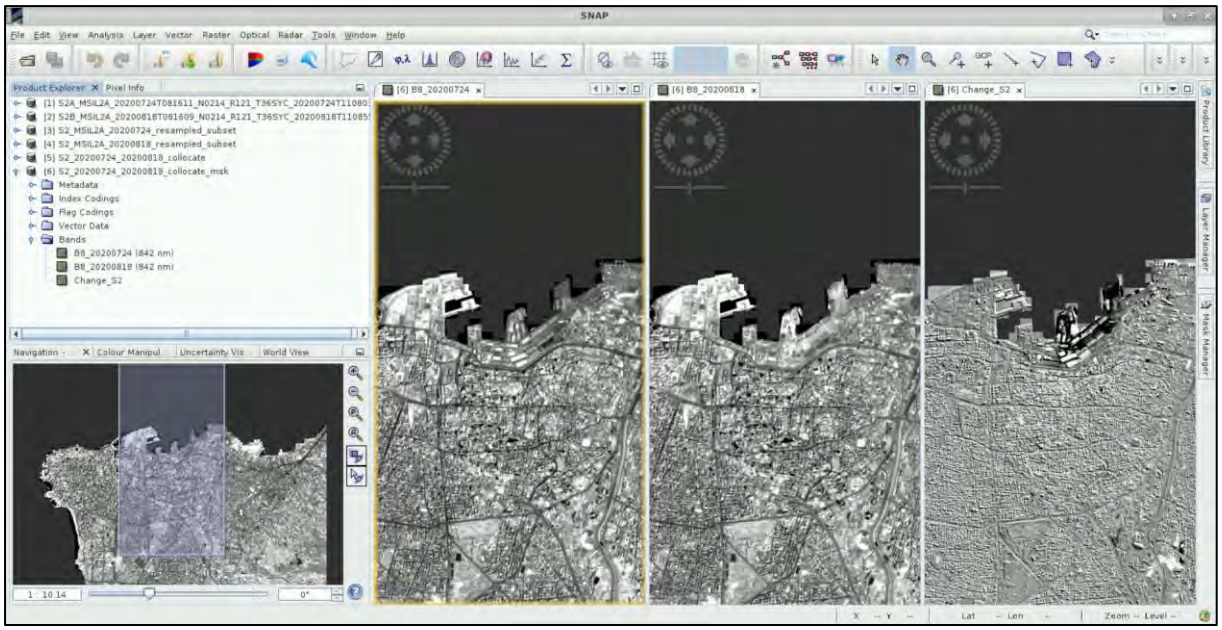


5.7.3 Band Maths

Next, we want to create the final band that will show us the areas that have been damaged. For this, we right-click on the **S2_20200724_20200818_collocate_msk** product and click on the "Band Maths". Set as "Name": **S2_change** and **deselect** the "Virtual (save expression only, don't store data) option". Then click on "Edit Expression" and insert the following: **B8_20200724 - B8_20200818**. Click **OK** in both windows. The new band will be created in the product. Double click and open it.



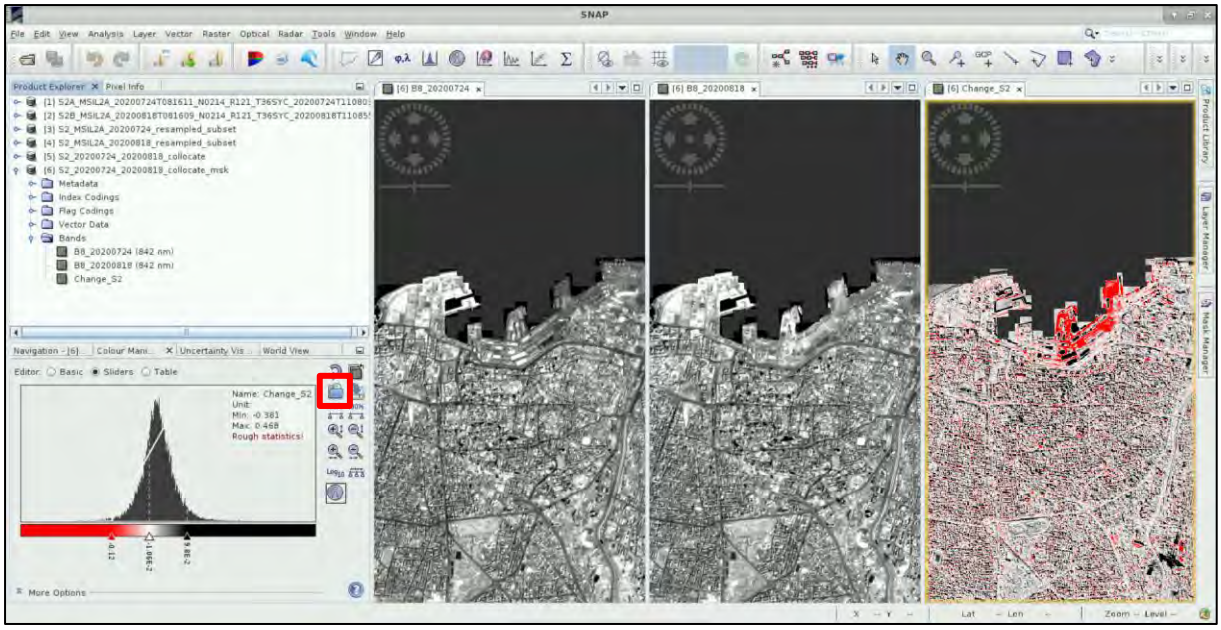




If you want to save this band, right click on the product and click on "Save Product".

Click on the **Import Colour Palette** icon. Then, navigate to the */shared/Training/HAZA08_LebanonDamageAssessment/AuxData* folder, select the **Damage_S2.cpd** and click **Open**.

At the window message that appears below, click **No**. In red we can see the areas that have been damaged from the explosion.

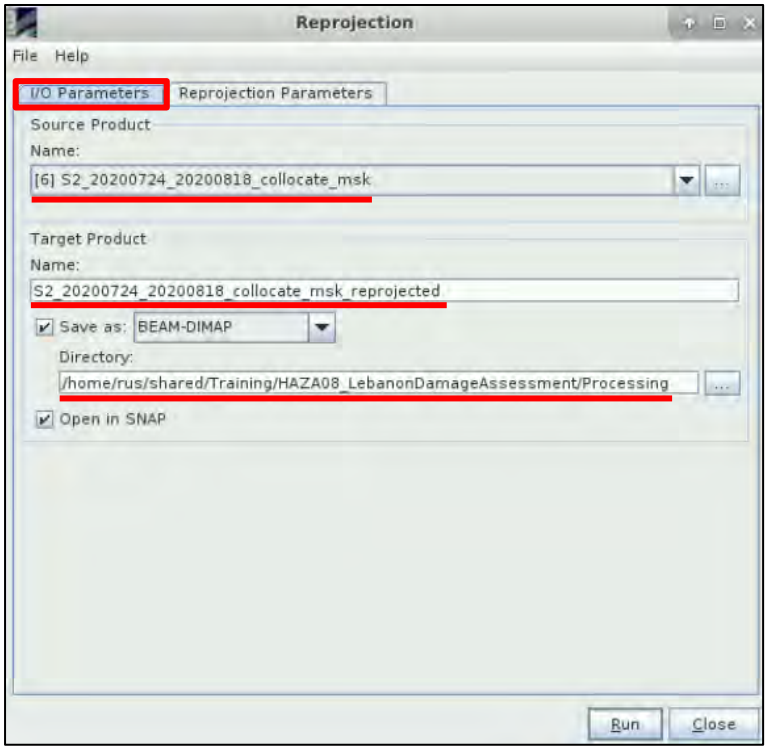


5.7.4 Reprojection

The last step is to reproject the product so that we can insert it in QGIS. Go to **Raster → Geometric Operations → Reprojection**.

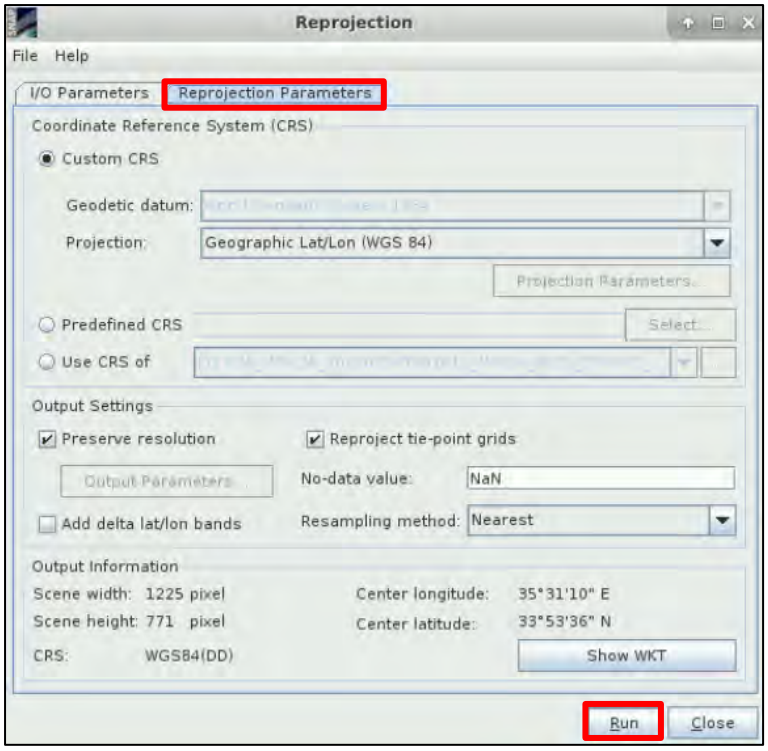
In the **I/O Parameters** tab set the following:

Source: S2_20200724_20200818_collocate_msk
Name: S2_20200724_20200818_collocate_msk_reprojected
Directory: */shared/Training/HAZA08_LebanonDamageAssessment/Processing*



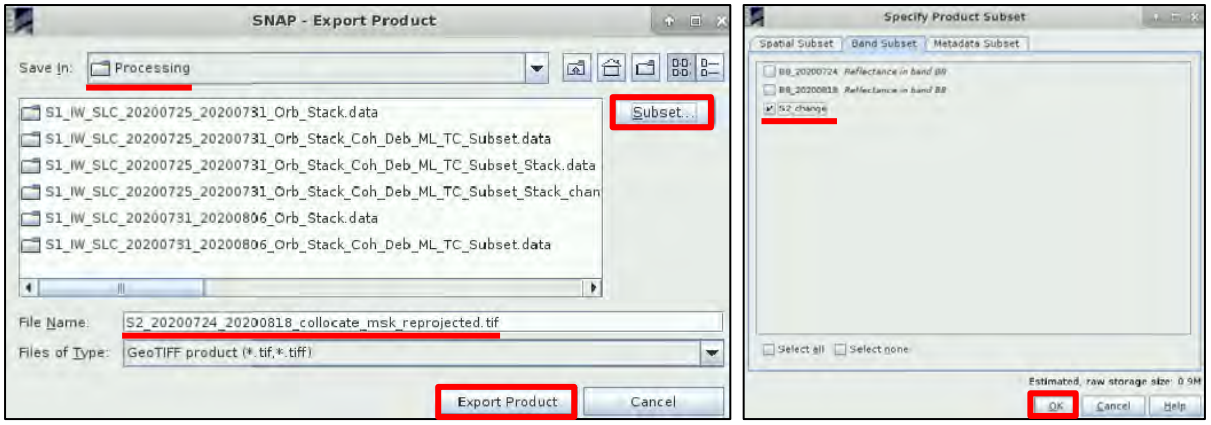
In the **Reprojection Parameters** tab, keep all the parameters as by default.

Click **Run**.



5.7.5 Export Sentinel-2 product

Select the *S2_20200724_20200818_collocate_msk_reprojected* product and go to **File → Export → GeoTIFF**. Click on **Subset** and select only the **S2_change** band. Click **OK**. The **File Name** will be set to S2_20200724_20200818_collocate_msk_reprojected.tif. At the **Save in** field, set the */shared/Training/HAZA08_LebanonDamageAssessment/Processing* path. Click **Export Product**.

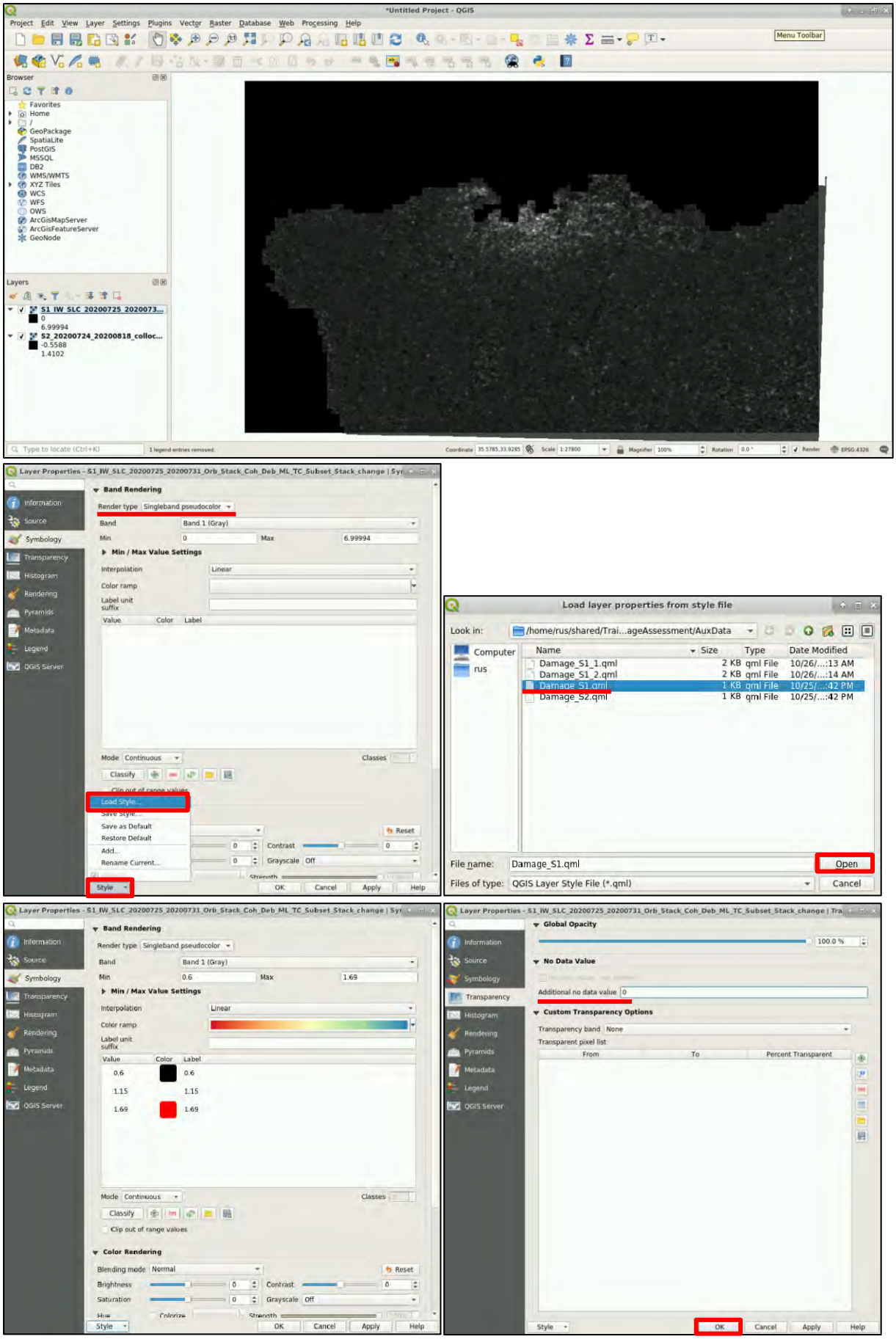


5.8 QGIS Visualization

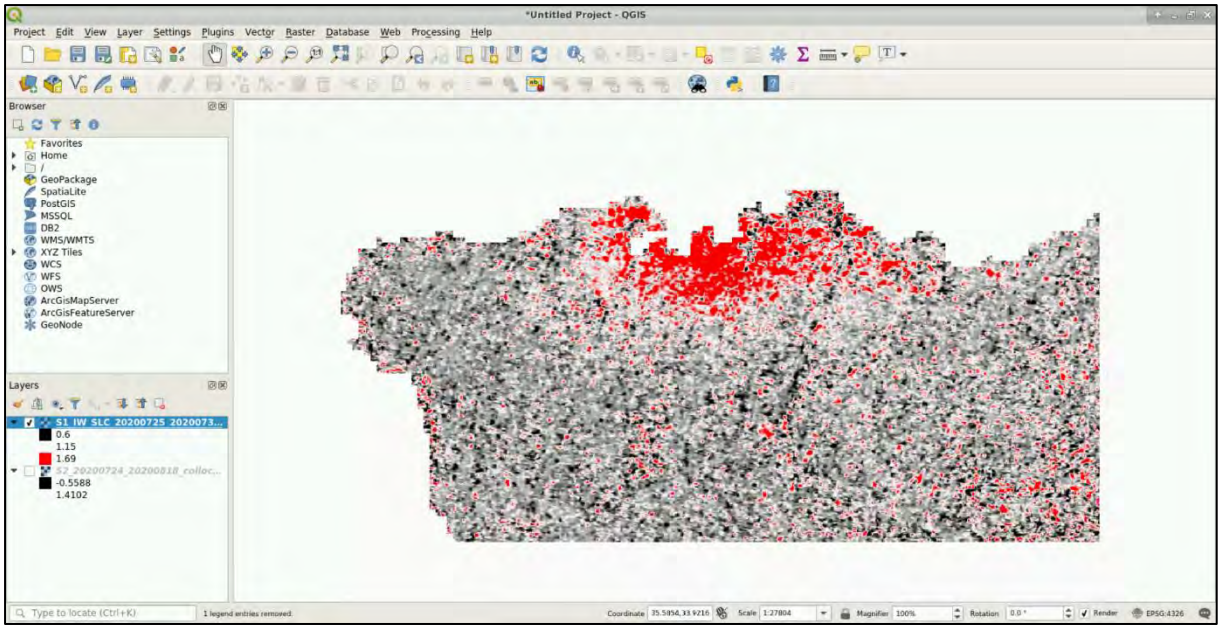
Open QGIS and load the **S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change.tif** and the **S2_20200724_20200818_collocate_msk_reprojected.tif** at the Layers panel. Right-click on the S1 product and go to "Properties".

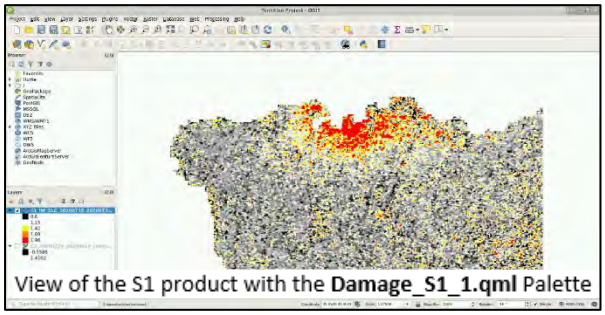
In the "Symbology" tab, set at "Render Type" **Singleband Pseudocolour**
On "Style", click and select "Load Style". Navigate to the */shared/Training/HAZA08_LebanonDamage Assessment/AuxData* folder, select **Damage_S1.qml** and click **Open** to load the palette.

We see that there is a black background in both images, so we will remove it by going in the "Transparency" tab and set as "Additional no data value": **0**

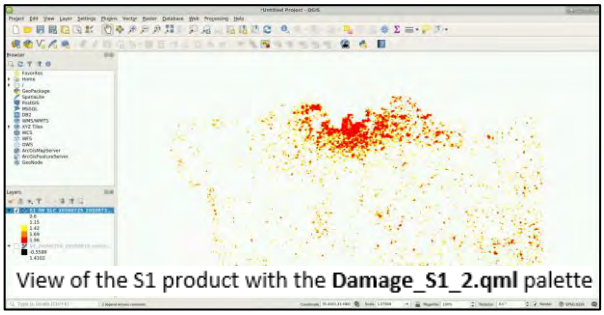

*Untitled Project - QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Menu Toolbar
Browser
Favorites
Home
GeoPackage
SpatiaLite
PostGIS
MSSQL
DB2
WMS/WMTS
XYZ Tiles
WCS
WFS
OWS
ArcGisMapServer
ArcGisFeatureServer
GeoNode
Layers
S1_IW_SLC_20200725_2020073...
S2_20200724_20200818_colloc...
Layer Properties - S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change | Sy
Band Rendering
Render type Singleband pseudocolor
Band Band 1 (Gray)
Min 0 Max 6.99994
Min / Max Value Settings
Interpolation Linear
Color ramp
Label unit suffix
Value Color Label
Mode Continuous
Classes
Classify
Load Style...
Save Style...
Save as Default
Restore Default
Add...
Rename Current...
Contrast
Grayscale Off
Reset
Style
OK Cancel Apply Help
Load layer properties from style file
Look in: /home/rus/shared/Trai...ageAssessment/AuxData
Computer
rus
Name Size Type Date Modified
Damage_S1_1.qml 2 KB qml File 10/26/...:13 AM
Damage_S1_2.qml 2 KB qml File 10/26/...:14 AM
Damage_S1.qml 1 KB qml File 10/25/...:42 PM
Damage_S2.qml 1 KB qml File 10/25/...:42 PM
File name: Damage_S1.qml
Open
Files of type: QGIS Layer Style File (*.qml)
Cancel
Layer Properties - S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change | Sy
Band Rendering
Render type Singleband pseudocolor
Band Band 1 (Gray)
Min 0.6 Max 1.69
Min / Max Value Settings
Interpolation Linear
Color ramp
Label unit suffix
Value Color Label
0.6 0.6
1.15 1.15
1.69 1.69
Mode Continuous
Classes
Classify
Clip out of range values
Color Rendering
Blending mode Normal
Brightness
Contrast
Saturation
Grayscale Off
Reset
Style
OK Cancel Apply Help
Layer Properties - S1_IW_SLC_20200725_20200731_Orb_Stack_Coh_Deb_ML_TC_Subset_Stack_change | Tra
Global Opacity
100.0 %
No Data Value
Additional no data value 0
Custom Transparency Options
Transparency band None
Transparent pixel list
From To Percent Transparent
Style
OK Cancel Apply Help

Click **OK**.



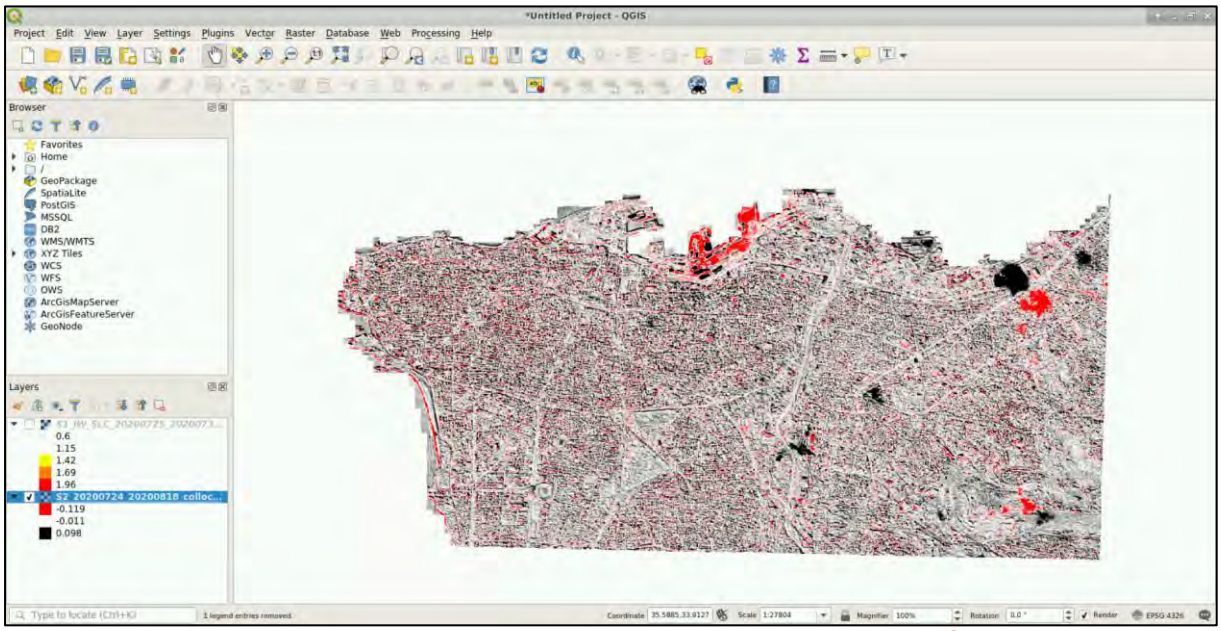


View of the S1 product with the **Damage_S1_1.qml** Palette



View of the S1 product with the **Damage_S1_2.qml** palette

Repeat the same steps for the Sentinel-2 product in the *Symbology* and the *Transparency* tabs, and when going at *Load Style*, select the **Damage_S2.qml** palette.

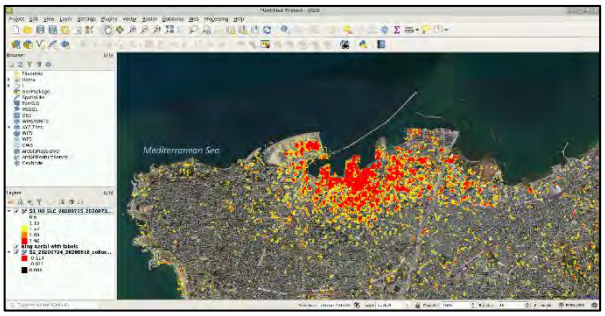


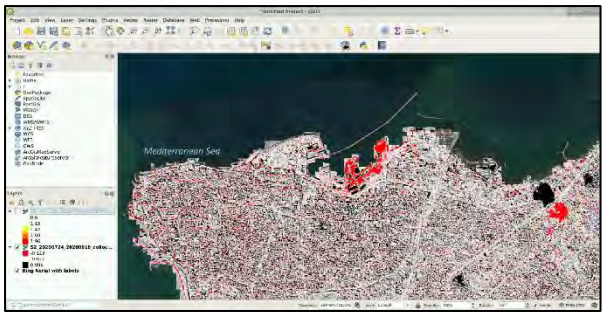
Go to **Web → OpenLayers plugin → Bing Maps → Bing Aerial with labels** (See NOTE 6).

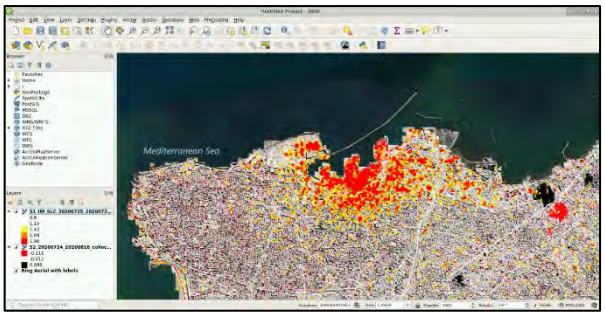
NOTE 6: In case the **OpenLayers** plugin is not installed, click on **Plugins** → **Manage and Install Plugins.** Select the *"All"* tab on the left side panel and write "OpenLayers plugin" on the search box. If you cannot find it, go to "Settings" and select the "Show also experimental plugins" option. Go back to the *"All"* tab, select the plugin on the list and click "Install Plugin". Restart QGIS to finalize the installation.

Now that we have added a basemap at the background, we can select which tif. files we want to visualize on the top of them.

For example, we see the Sentinel-1 product with the **Damage_S1_2** palette (right), the Sentinel-2 product with the **Damage_S2** palette, (bottom left) and both S-1 and S-2 products (bottom right)





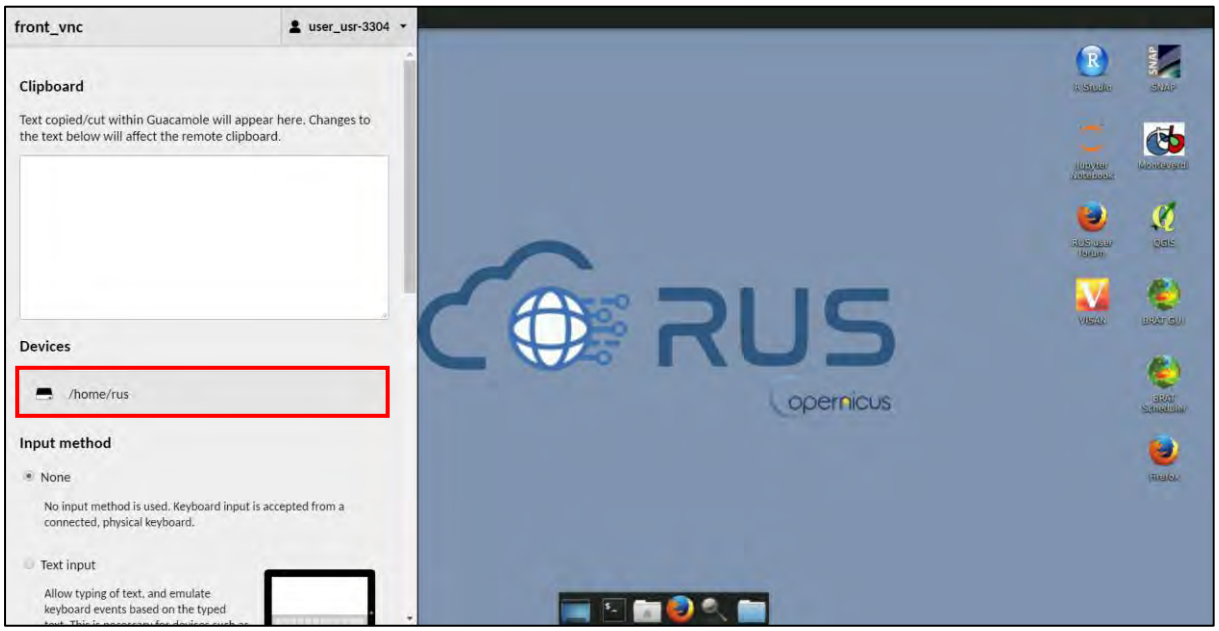


6 Extra Steps

6.1 Download files from VM

In your VM, press **Ctrl+Alt+Shift.**

A pop-up window will appear on the left side of the screen. Click on the bar below **Devices**, navigate to the folders you have saved the files you want to download and **double click** on them. The downloading process to your local computer will start automatically.



THANK YOU FOR FOLLOWING THE EXERCISE!

7 Further reading and resources

- https://sentinel.esa.int/web/sentinel/missions/sentinel-1 - Sentinel-1 Mission
- https://sentinel.esa.int/web/sentinel/missions/sentinel-2 - Sentinel-2 Mission

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