

TRAINING KIT – HAZA01

FLOOD MONITORING WITH SENTINEL-1 USING S-1
TOOLBOX - JANUARY 2015, MALAWI



Research and User Support for Sentinel Core Products

The RUS Service is funded by the European Commission, managed by the European Space Agency and operated by CSSI and its partners.

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

Cover images produced by RUS Copernicus

The following training material has been prepared by Serco Italia S.p.A. within the RUS Copernicus project.

Date of publication: October 2018 (Revision – February 2019)

Version: 1.2

Suggested citation:

Serco Italia SPA (2018). *Flood Monitoring with Sentinel-1 Using S-1 Toolbox - January 2015, Malawi (version 1.2)*. Retrieved from RUS Lectures at <https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/>



This work is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

DISCLAIMER

While every effort has been made to ensure the accuracy of the information contained in this publication, RUS Copernicus does not warrant its accuracy or will, regardless of its or their negligence, assume liability for any foreseeable or unforeseeable use made of this publication. Consequently, such use is at the recipient's own risk on the basis that any use by the recipient constitutes agreement to the terms of this disclaimer. The information contained in this publication does not purport to constitute professional advice.

Table of Contents

1	Introduction to RUS.....	3
2	Training.....	3
2.1	Data used.....	3
2.2	Software in RUS environment.....	3
3	Register to RUS Copernicus.....	4
4	Request a RUS Copernicus Virtual Machine.....	5
5	Step by step.....	8
5.1	Data download – ESA SciHUB.....	8
5.2	SNAP – open and explore data.....	11
5.3	Pre-processing.....	12
5.3.1	Build the Graph.....	12
5.3.2	Batch processing.....	14
5.4	Binarization.....	17
5.5	Visualization (QGIS).....	22
6	Further reading and resources.....	25

1 Introduction to RUS

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 derived from the Copernicus Sentinel satellites constellation.



Malawi floods January 2015 Credits: www.theguardian.com
[February 10, 2015]

The Republic of Malawi declared a State of Disaster on 13 January 2015 in the 15 affected districts (out of a total of 28 districts). The southern districts of Nsanje, Chikwawa, Phalombe and Zomba were the most affected.

The area experienced heavy rains, more than 150% of normal rainfall, throughout December and January, partially related to Cyclone Bansi and Tropical Storm Chedza, which led to severe flooding. The flood left 276 people dead and

estimated 230 000 displaced with some areas completely inaccessible. It also caused extensive damage to crops, livestock and infrastructure with estimated 64 000 hectares of land damaged, further deepening the humanitarian disaster.

2 Training

Approximate duration of this training session is one hour.

The Training Code for this tutorial is **HAZA01**. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the [RUS portal](#) and open a User Service request from Your RUS service → Your dashboard.

2.1 Data used

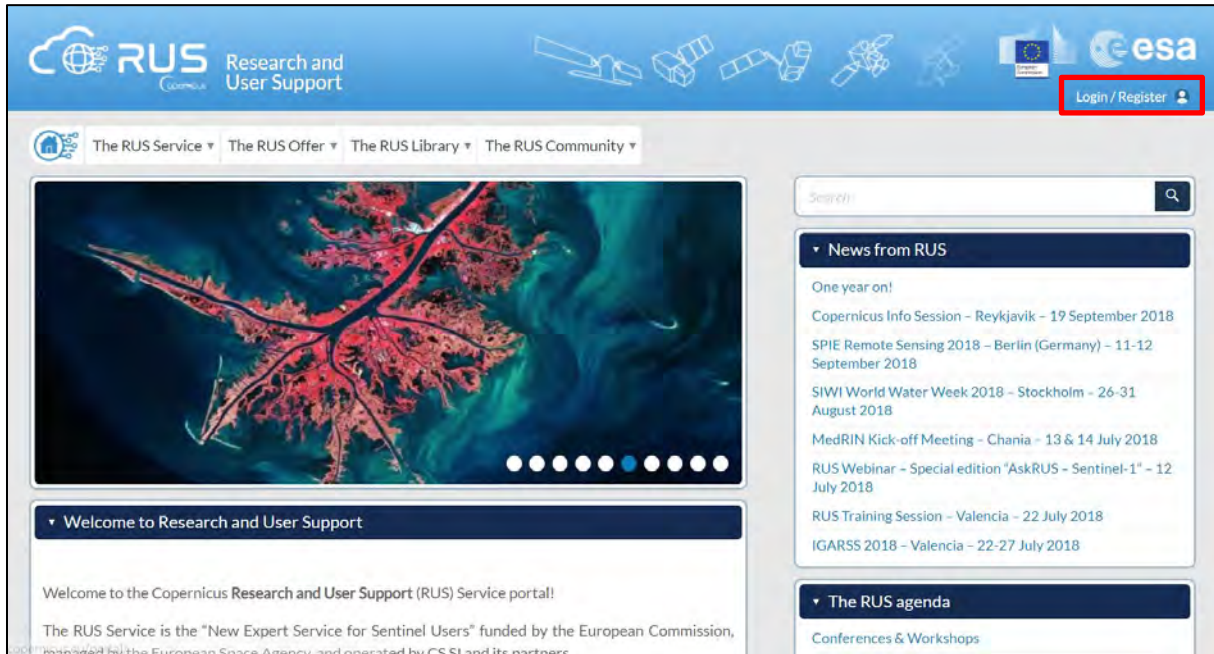
- Four Sentinel-1A IW GRDH images with VV polarization acquired before the flood event on 29 December 2014 and during the flood event on 22 January, 27 February and 23 March 2015 [downloadable @ <https://scihub.copernicus.eu/>]
S1A_IW_GRDH_1SSV_20150323T030724_20150323T030752_005153_0067F3_832F.zip
S1A_IW_GRDH_1SSV_20150227T030723_20150227T030752_004803_005F89_DB68.zip
S1A_IW_GRDH_1SSV_20150122T030723_20150122T030752_004278_005347_8809.zip
S1A_IW_GRDH_1SSV_20141229T030724_20141229T030753_003928_004B86_DA25.zip
- Sentinel-1 Precise Orbits (PODs) for the corresponding dates (auxiliary data) automatically downloaded [downloadable @ <https://qc.sentinel1.eo.esa.int>]

2.2 Software in RUS environment

Internet browser, SNAP + Sentinel-1 Toolbox, 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**.

Login / Register

Registered RUS users, as well as persons who already own a Copernicus SSO account, can directly access our service.

Login

Newcomers shall first create an account on the Copernicus Single Sign-On (SSO) authentication server used to support registration to the RUS service.

Create my Copernicus SSO account

NB: persons using a Google e-mail address for registration shall check their mailbox spam folder regularly as Google tends to filter RUS e-mails.

Close

esa cbS-SSO

Copernicus Users' Single Sign On Registration

Registration form

I'm already registered: ☐

GDS SSO ID:

Secret question: Select one (optional)

Answer:

Password:

Confirm password:

Email:

Confirm email:

First name:

Last name:

Institution:

Country of residence:

Type the characters: **Register**

© Copernicus Single Sign On 3.5.0 © 2018 05-21

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.

Login / Register

The registration system to access the RUS service platform has moved toward the COPERNICUS Single Sign On authentication server.

- New Users who have not yet registered to the RUS portal shall first create a COPERNICUS SSO account.

Note that your Copernicus SSO account will be activated only after the reception of the third email sent by the Copernicus service. We advise you to consult [this document](#) and [this page](#) to facilitate your registration procedure.

REGISTER COPERNICUS SSO account

Users who already have a COPERNICUS SSO account can login here:

Login

Close

Credentials

CDS-SSO ID

Password

Max Idle Time

Max Session Time

Login **Reset**

[Forgot your password?](#)

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

Do you want to subscribe for a new RUS account?

Your ESA-SSO subscription data:

Login

First Name

Last Name

Email

Organization

Country

Additional subscription information

Please complete the following information:

Where did you hear about the RUS service?
Select one or more items:

outreach event
colleagues
newsletter
conference
social media
other

Institution type

Phone number

Title

Subscribe **Cancel**

4 Request a RUS Copernicus Virtual Machine

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 Dashboard**.

RUS Research and User Support

Hello, Miguel

The RUS Service The RUS Offer The RUS Library The RUS Community **Your RUS service**

Your RUS service

This section gathers pages related to your RUS services:

- Your profile:** displays your personal information linked to your ESA SSO and RUS accounts,
- Your dashboard:** allows you to access your private dashboard,
- Your training:** allows you to register to a training session you have been invited to participate in.

News from RUS

One year on!

Copernicus Info Session - Reykjavik - 19 September 2018

SPIE Remote Sensing 2018 - Berlin (Germany) - 11-12 September 2018

SIWI World Water Week 2018 - Stockholm - 26-31 August 2018

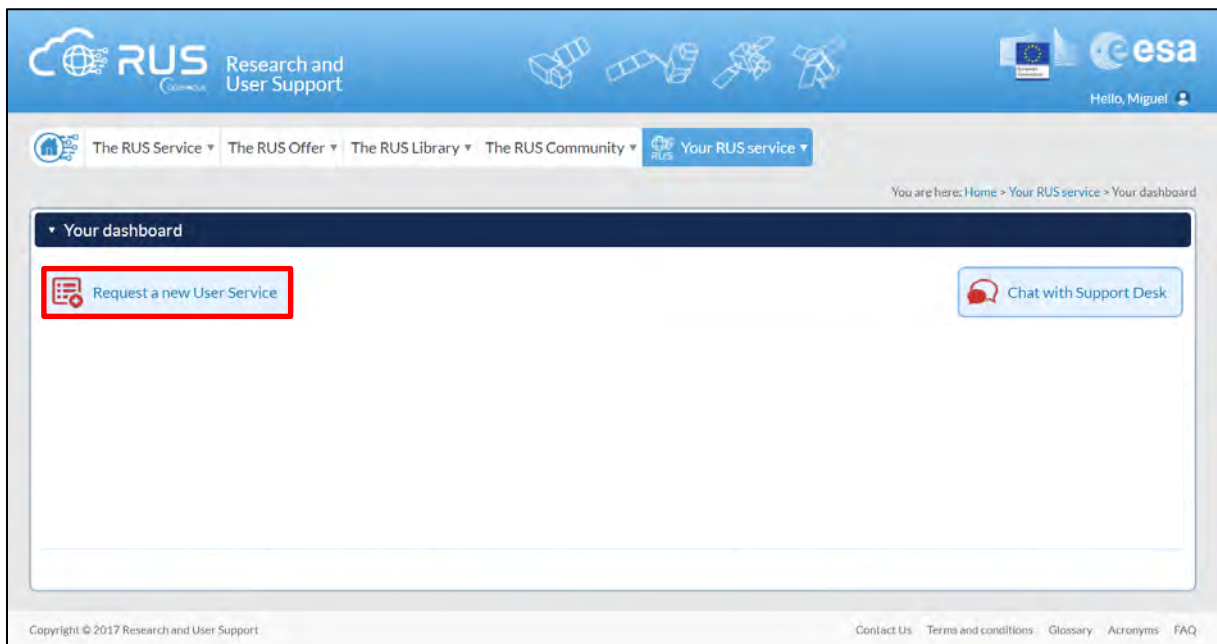
MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018

RUS Webinar - Special edition "AskRUS - Sentinel-1" - 12 July 2018

RUS Training Session - Valencia - 22 July 2018

IGARSS 2018 - Valencia - 22-27 July 2018

Click on **Request a new User Service** to request your RUS Virtual Machine. Complete the form so that the appropriate cloud environment can be assigned according to your needs.



If you want to repeat this tutorial (or any previous one) select the one(s) of your interest in the appropriate field.

The image displays the 'User Support Request' form, specifically Step 1/3 titled 'Your experience'. The form prompts the user to provide background information. It includes questions about years of experience in Remote Sensing and whether the user has downloaded or handled Copernicus data. A red rectangular box highlights a section asking if the user wishes to practice a tutorial exercise shown in a RUS webinar. This section contains a list of exercises: HAZA01 - Flood Mapping in Malawi, HAZA02 - Burned Area Mapping in Portugal, HYDR01 - Water Bodies Mapping over Northern Poland, LAND01 - Crop Mapping in Seville, LAND04 - Land Monitoring in Cyprus, and OCEA01 - Ship Detection in Gulf of Trieste. Below the list, there is a text input field for requesting exercises not on the list. At the bottom of the form are 'Cancel' and 'Next' buttons.

Complete the remaining steps, check the terms and conditions of the RUS Service and submit your request once you are finished.

User Support Request

Summary information on your request:

This is a collection of information selected across the USR forms.

You can go back and edit this information if necessary.

General information on your request:

Years of experience in Remote Sensing

5-10 years

Downloaded Copernicus data?

✓

Handled/processed Copernicus data?

✓

Webinar codes

HAZA02, LAND04

About your RUS project:

Thematic area

Cryosphere (ice and snow)

Operations to perform on RUS

Algorithm development

Preference for downloading process

Self-downloading

Foreseen activities and support needs

Develop a land cover classification

Project name

RUS_Project1

Earth Observation Data information:

Type of Earth Observation Data:

Sentinel-1

✓

S1 - Product type

S1 - Product 1

S1 - Sensor mode

GRD

S1 - Polarisation

-

S1 - Orbit direction

-

Sentinel-2

X

Sentinel-3

X

Other

X

I don't know

X

Region of Interest:

Min Latitude

39.3303

Max Latitude

40.5877

Min Longitude

-4.6736

Max Longitude

-2.7205

Reference polygons

Data acquisition date(s):

None

Additional data specifications

☒ I have read and agree to the Terms and conditions of RUS Service.

Back and edit

Submit the request

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**.

RUS

Research and User Support

Hello, Miguel

The RUS Service

The RUS Offer

The RUS Library

The RUS Community

Your RUS service

You are here: Home > Your RUS service > Your dashboard

Your dashboard

Request a new User Service

Chat with Support Desk

Project Name	ID	Date of submission	Status	Actions			Virtual Environment	
RUS_training1	231	2017-08-31	Open	Follow my project	Get support	Close my service	Access my Virtual Machine(s)	Access my CPU monitoring dashboard
				Cancel my request	Get a webinar kit	Rate my service ★★★★★	Freeze my Virtual Machine(s)	Report a technical incident

Copyright © 2017 Research and User Support

Contact Us

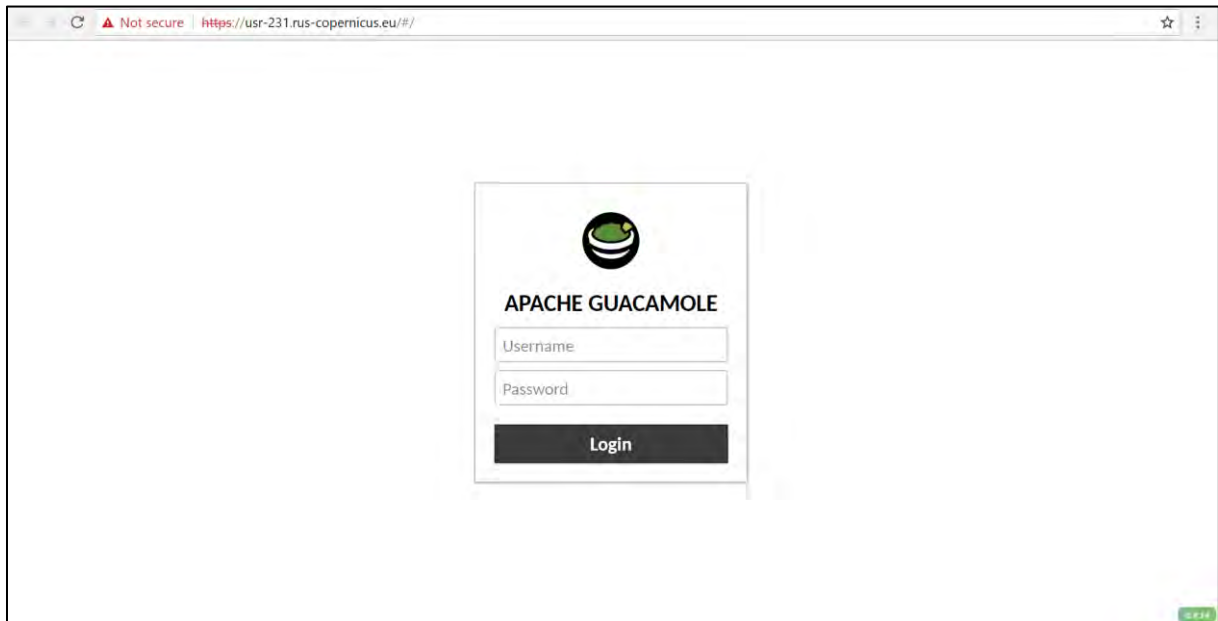
Terms and conditions

Glossary

Acronyms

FAQ

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.

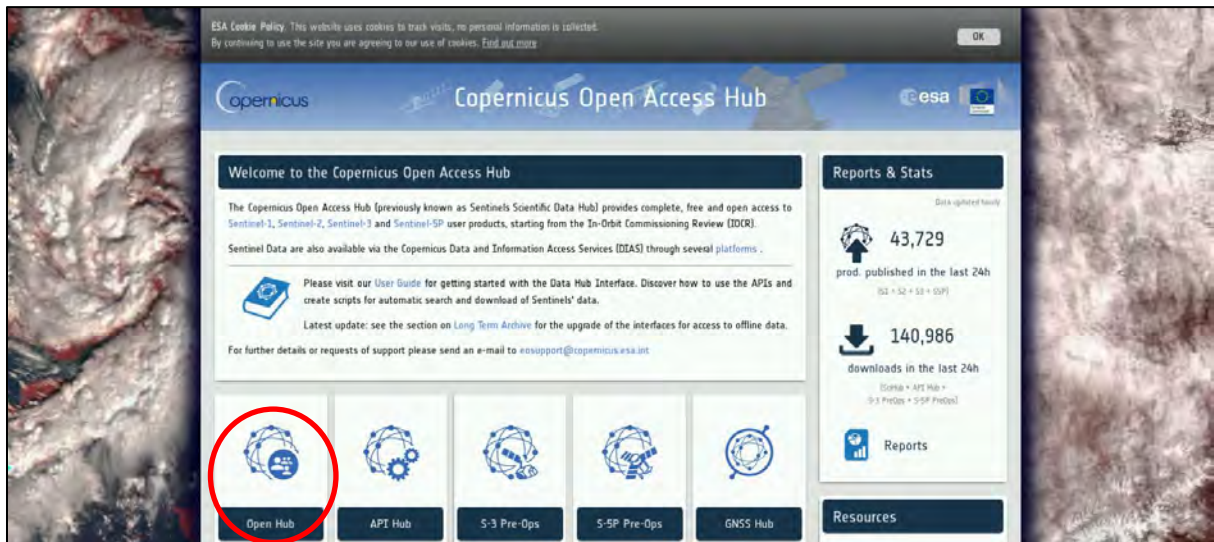


5 Step by step

5.1 Data download – ESA SciHUB

In this step, we will download Sentinel-1 scenes from the Copernicus Open Access Hub using the online interface (**Applications** → **Network** → **Firefox Web Browser** or click the link below).

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



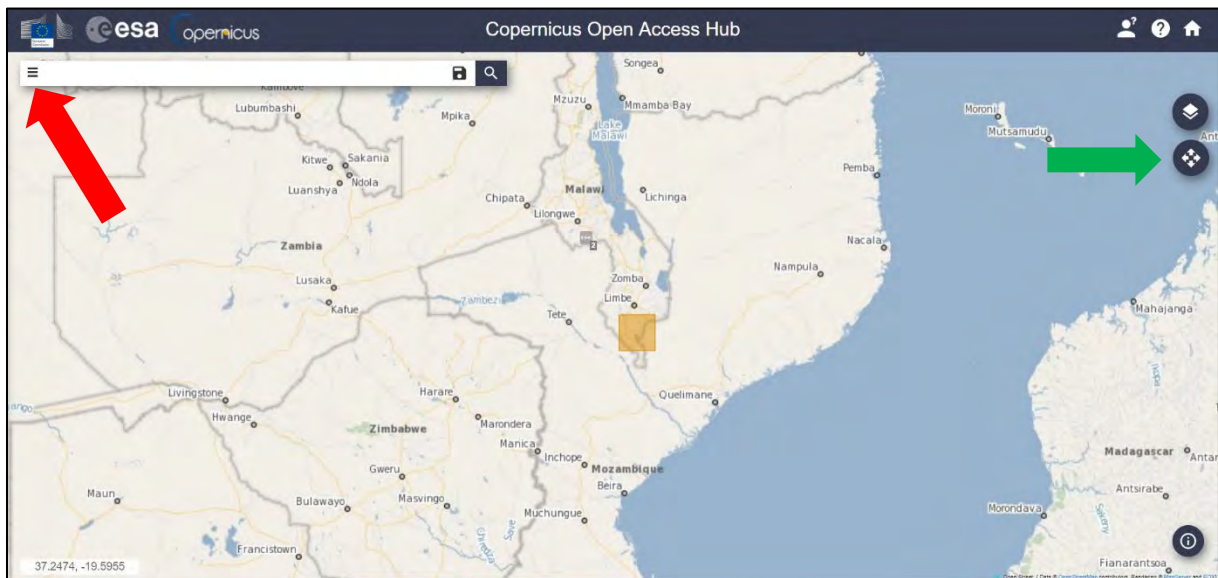
Go to **“Open HUB”**, if you do not have an account please register by going to **“Sign-up”** in the LOGIN menu in the upper right corner.



The screenshot shows the Copernicus Open Access Hub registration form. The form is titled 'Register new account'. It includes a welcome message and instructions for registration. The form fields are: Firstname, Lastname, Username, Password, Confirm Password, E-mail, and Confirm E-mail. There are also dropdown menus for 'Select Domain', 'Select Usage', and 'Select your country'. A red arrow points to the 'REGISTER' button at the bottom right of the form.

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”**.

Then click on the map and Navigate to the approximate location of south Malawi. Switch to drawing mode (green arrow) and draw search rectangle approximately as indicated below.



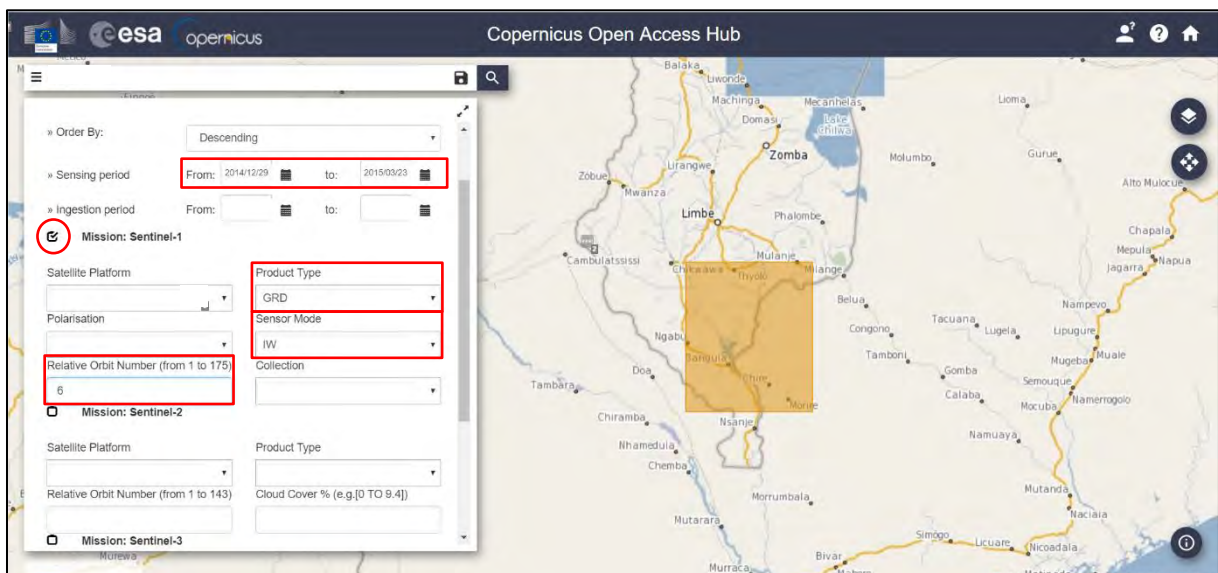
Open the search menu by clicking to the left part of the search bar and specify the following parameters:

Sensing period: From 2014/12/29 to 2015/03/23

Check Mission: Sentinel-1

Product Type: GRD (Ground-range-detected product)

Relative Orbit number: 6 (to ensure identical acquisition geometry for all scenes)



In our case, the search returns only 11 results but this will depend on the exact search area defined. Download the following scenes:

S1A_IW_GRDH_1SSV_20150323T030724_20150323T030752_005153_0067F3_832F

S1A_IW_GRDH_1SSV_20150227T030723_20150227T030752_004803_005F89_DB68

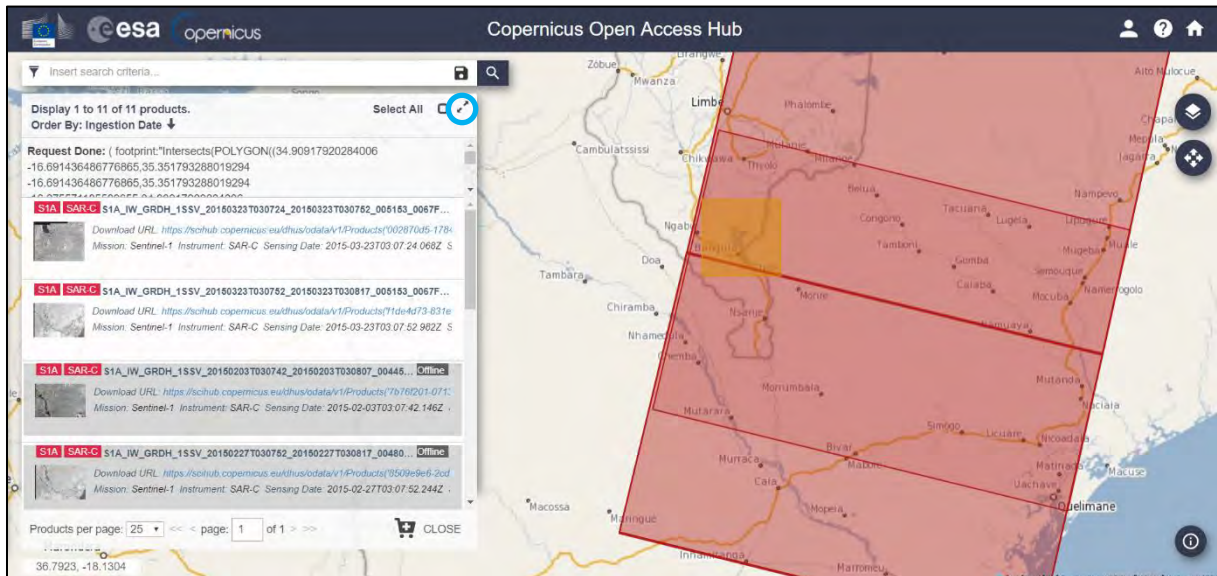
S1A_IW_GRDH_1SSV_20150122T030723_20150122T030752_004278_005347_8809

S1A_IW_GRDH_1SSV_20141229T030724_20141229T030753_003928_004B86_DA25

Note that you can only download 2 scenes in parallel. To see the full name of the scene you can click the full screen view (indicated by blue circle below).





You can find instructions how to download larger numbers of products in the Copernicus Open Access Hub User Guide (<https://scihub.copernicus.eu/userguide/GraphicalUserInterface>)

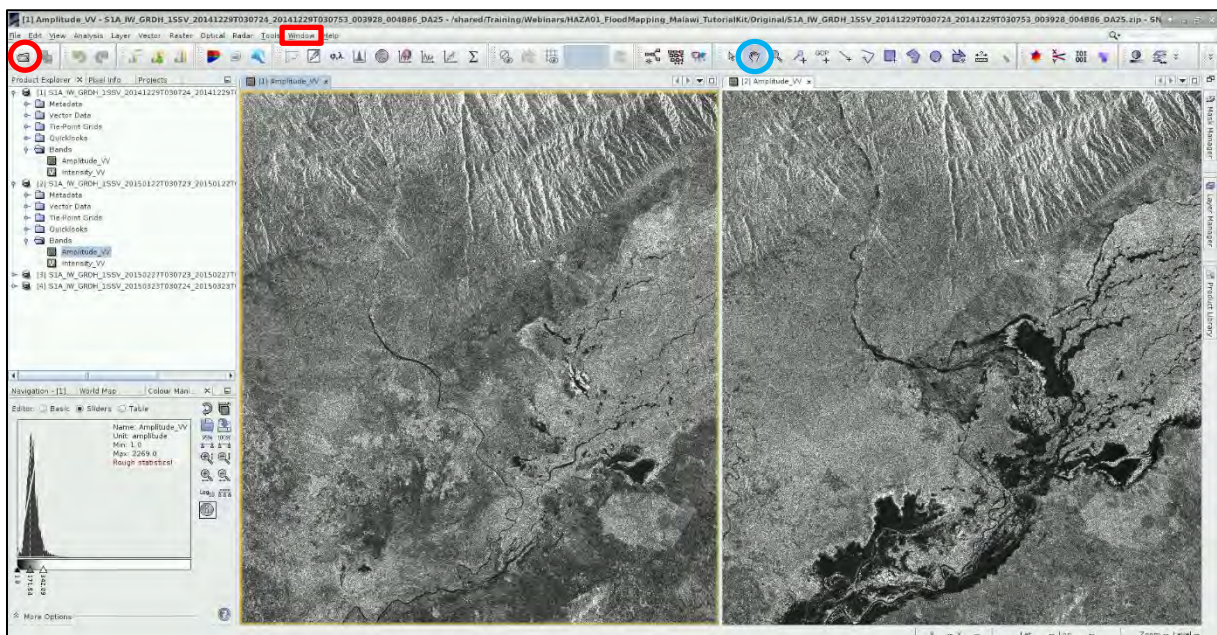


Move the downloaded scenes from the *Downloads* folder (*/home/rus/Downloads*) to:
/shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Original

5.2 SNAP – open and explore data

Open **SNAP Desktop** (icon located on the desktop); click Open product , navigate to: ***/shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Original*** and open all the downloaded files.

The opened products will appear in **Product Explorer**. Click + or the  to expand the contents of the file from December 2014, then expand Bands and double click **Amplitude_VV** to visualize the band. Then do the same for the image from 22 January 2015. To compare both images, go to **Window → Tile Horizontally** and zoom-in to the lower right corner of the image.

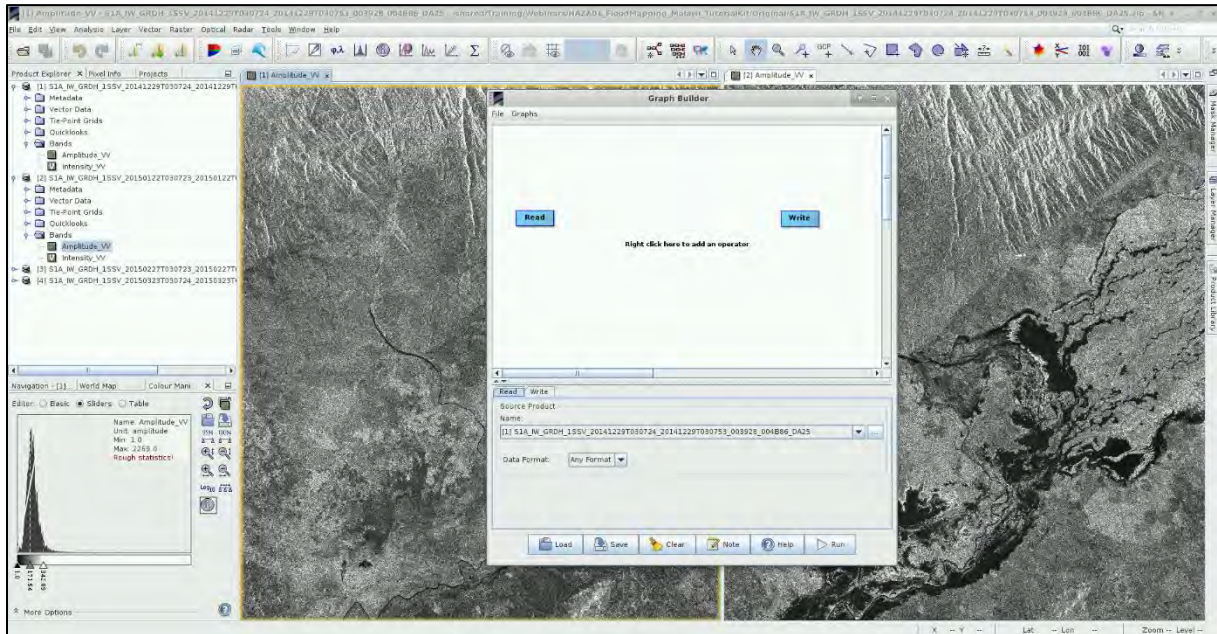


5.3 Pre-processing

We need to apply identical pre-processing steps to all our scenes. However, processing the data step by step and product by product would be time consuming and inconvenient. Luckily, we can use the **Batch Processing** tool available in SNAP to apply all steps to both images in one go (this also saves disk space as only the final products are physically saved).

5.3.1 Build the Graph

To use the tool, we first need to define the process we want to apply and all its steps. We can do this using the **GraphBuilder**. To build our graph, go to **Tools → GraphBuilder**.





At the moment, the graph only has two operators: **Read** (to read the input) and **Write** (to write the output).

Since our Area of Interest (AOI) is quite small and there is no need to process the whole image, we start by adding a **Subset** operator. To add the operator right-click the white space in the graph builder and go to **Add → Raster → Geometric → Subset**.


A new operator rectangle appears in our graph and a new tab appears below. Now connect the new **Subset** operator to the **Read** operator by clicking to the right side of the **Read** operator and dragging the red arrow towards the **Subset**.




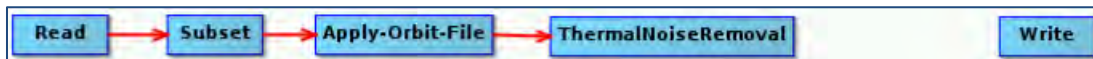
In the next step, we will update the orbit metadata (See  NOTE 1). To add the operator, right-click the white space between existing operators and go to **Add → Radar → Apply-Orbit-File**. Connect the new **Apply-Orbit-File** operator with the **Subset** operator.


 **NOTE 1:** 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](#)*)




The next step will remove the thermal noise (See  NOTE 2). We do this by right-clicking the white space and going to **Add → Radar → Radiometric → ThermalNoiseRemoval**. Connect the **ThermalNoiseRemoval** operator with the **Apply-Orbit-File** operator.


 NOTE 2: Thermal noise in SAR imagery is the background energy that is generated by the receiver itself. (SNAP Help) It skews the radar reflectivity to towards higher values and hampers the precision of radar reflectivity estimates. Level-1 products provide a noise LUT for each measurement dataset, provided in linear power, which can be used to remove the noise from the product.




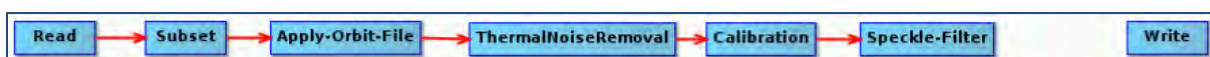
Now, we can add the **Calibration** operator. The objective of SAR calibration is to provide imagery in which the pixel values can be directly related to the radar backscatter. Though uncalibrated SAR imagery is sufficient for qualitative use, calibrated SAR images are essential to quantitative use of SAR data (See  NOTE 3). To add the operator go to **Add → Radar → Radiometric → Calibration**. Connect the **ThermalNoiseRemoval** operator to the **Calibration** operator.


 NOTE 3: Typical SAR data processing, which produces level-1 images, does not include radiometric corrections and significant radiometric bias remains. The radiometric correction is necessary for the pixel values to truly represent the radar backscatter of the reflecting surface and therefore for comparison of SAR images acquired with different sensors or acquired from the same sensor but at different times, in different modes, or processed by different processors. (SNAP Help)




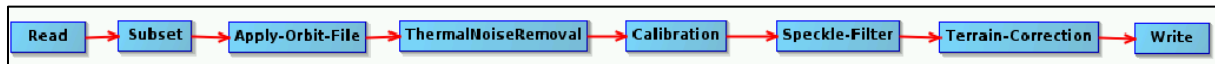
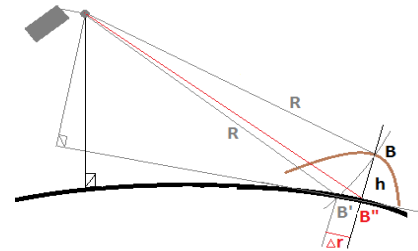
SAR images have inherent salt and pepper like texturing called speckles which degrade the quality of the image and make interpretation of features more difficult (See  NOTE 4). To reduce the speckle effect and smooth the image we apply speckle filter. To add the operator, go to **Radar → Speckle Filtering → Speckle-Filter** then connect the **Calibration** operator to it.

 NOTE 4: Speckle is caused by random constructive and destructive interference of the de-phased but coherent return waves scattered by the elementary scatters within each resolution cell. Speckle noise reduction can be applied either by spatial filtering or multilook processing. (SNAP Help)



Our data are still in radar geometry, moreover due to topographical variations of a scene and the tilt of the satellite sensor, the distances can be distorted in the SAR images. Therefore, as the last step of our preprocessing, we will apply terrain correction to compensate for the distortions and reproject the scene to geographic projection (See  NOTE 5). To add the operator, go to **Radar → Geometric → Terrain Correction → Terrain-Correction** and then connect the **Speckle-Filter** operator to it. Finally, connect the **Terrain Correction** operator to the **Write** operator.

 **NOTE 5:** The geometry of topographical distortions in SAR imagery is shown on the right. Here we can see that point **B** with elevation **h** above the ellipsoid is imaged at position **B'** in SAR image, though its real position is **B"**. The offset Δr between **B'** and **B"** exhibits the effect of topographic distortions. (SNAP Help)



For the moment, do not change anything in the parameter tabs and save the graph as **Graph_preprocess.xml** to:

/shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Processing by clicking **Save** at the bottom of the window. After you save the graph, close the **GraphBuilder** window.


5.3.2 Batch processing

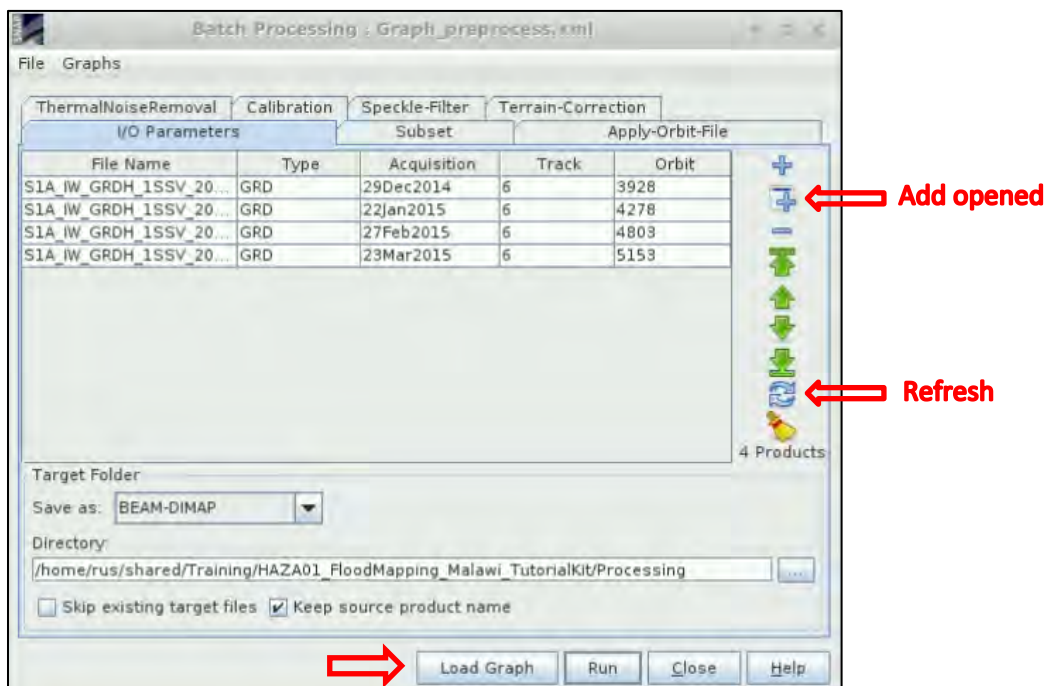
In the **Product Explorer**, we select (highlight) the product [1] (29 December 2014). Now we can open the **Batch Processing** tool at **Tools → Batch Processing**.

We will add the opened products by clicking **Add Opened** on the upper right (second icon from the top) and click **Refresh**. Then click **Load Graph** at the bottom of the window and navigate to our saved graph and open it. We see that new tabs have appeared at the top of window corresponding to our operators except for **Write**; this is correct as these parameters will be set in the **I/O Parameters** tab.

In the **I/O Parameters** tab, set directory to:

/shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Processing and make sure the “**Keep source product name**” option is selected (See  NOTE 6).

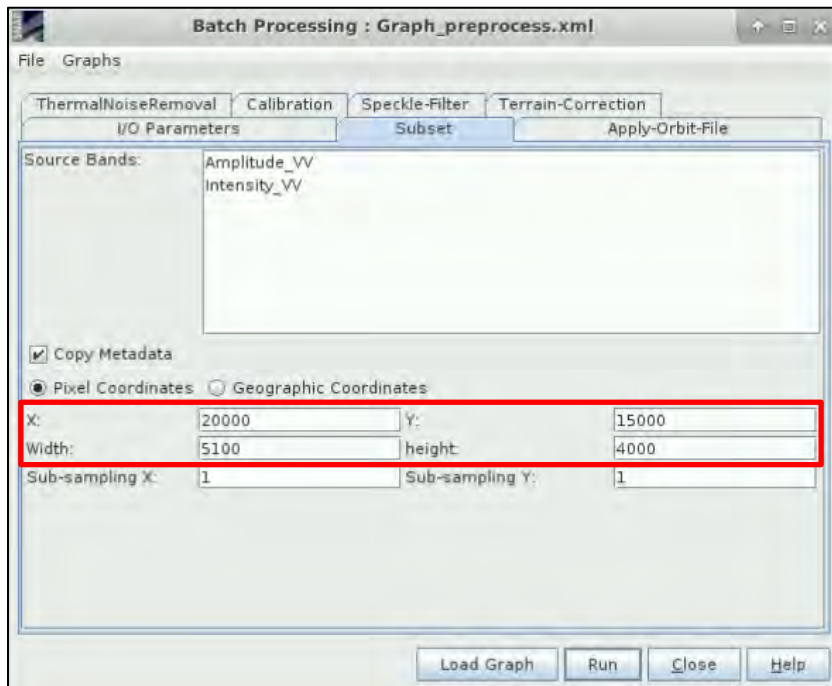
 **NOTE 6:** The product file names will be identical to the input file names. If you set your output directory to the folder that contains your input data, the input data will be overwritten!



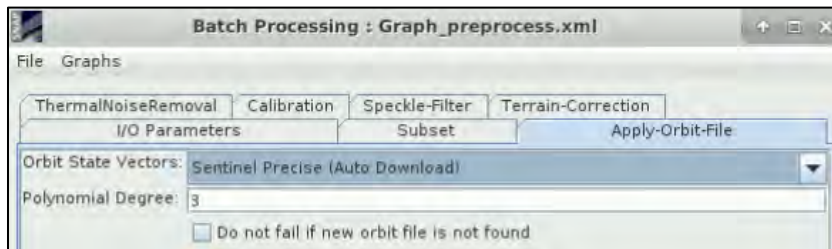
Now let's set the parameters.

In the **Subset** tab, set the extent of the AOI in pixel coordinates to:

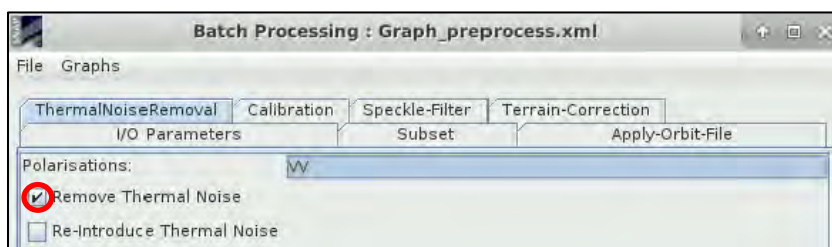
X: **20000** Y: **15500** Width: **5100** Height: **4000**



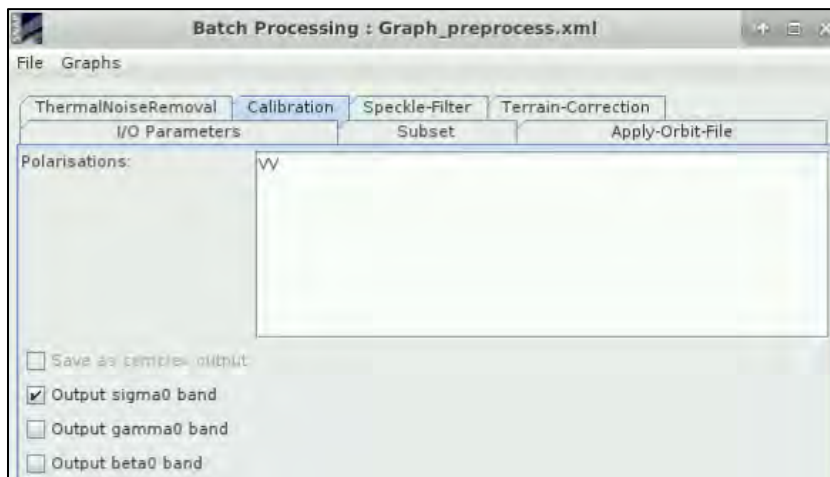
In the **Apply-Orbit-File** tab we will keep the default settings.




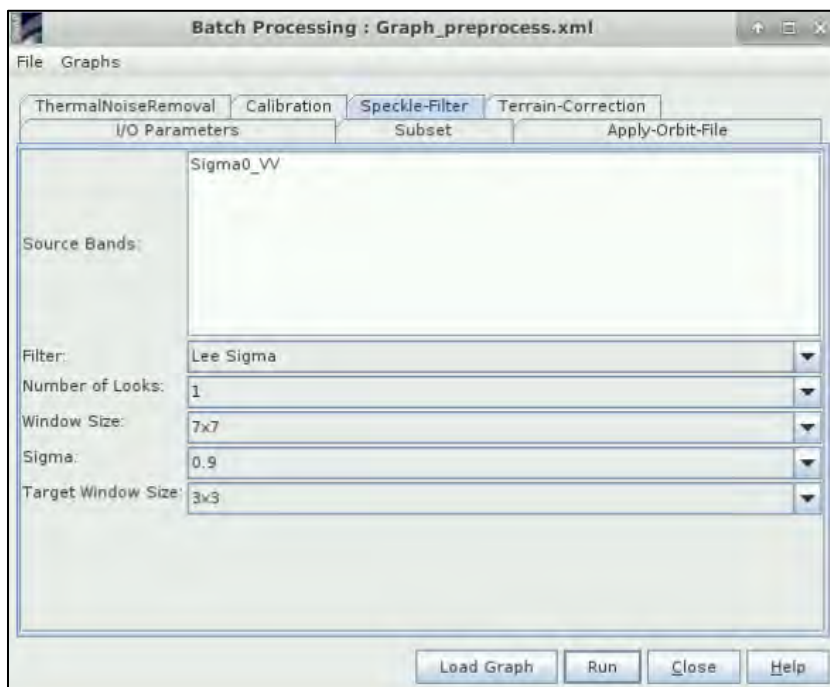
In the **ThermalNoiseRemoval** tab, select VV polarization and make sure that the “**Remove Thermal Noise**” option is selected.




In the **Calibration** tab, we will also keep all default settings.



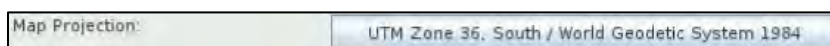
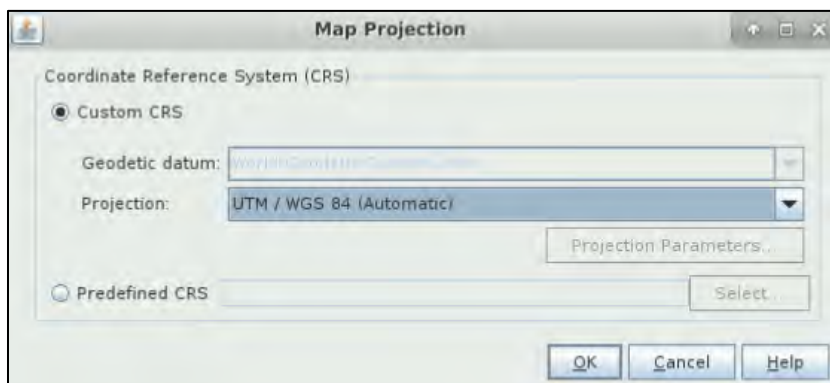
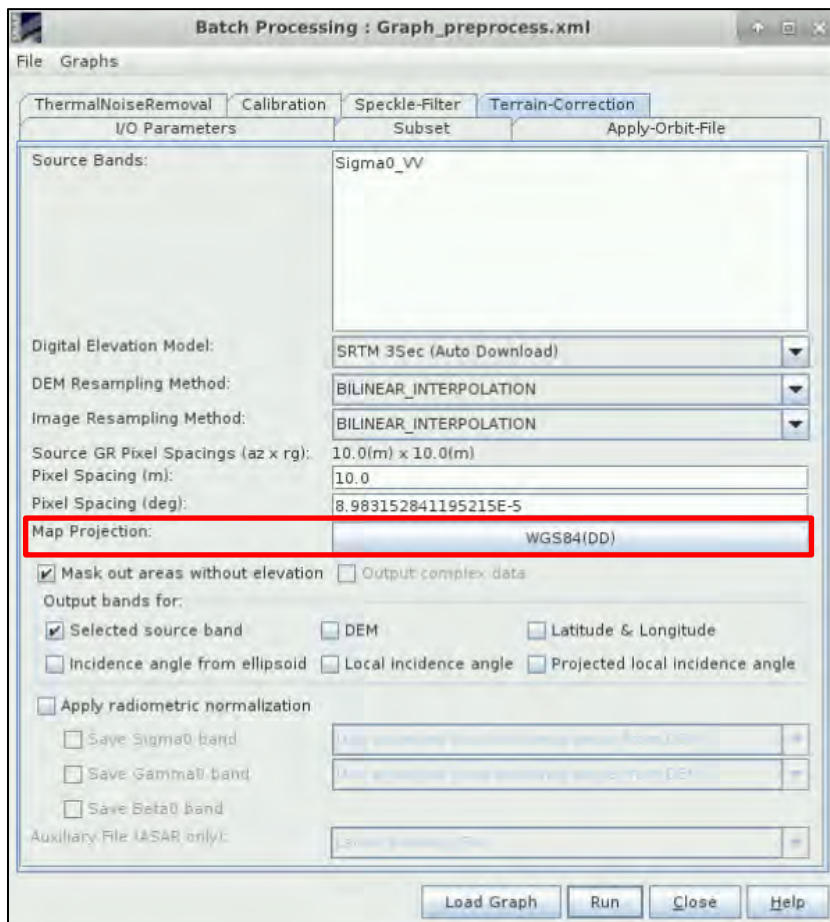
Now we go to the **Speckle-Filter** tab. For this exercise we choose the simple Lee filter with **Window Size** of **7x7** pixels (See  NOTE 7).



 NOTE 7: Lee Filter, introduced by Jong-Sen Lee in 1980, is a widely used local statistics filter for speckle noise reduction. It is a pointwise linear filter minimizing the mean square error using measurements of the sample mean and sample variance of the noisy image and knowledge of the type of detection and number of looks.

Last, we go in the **Terrain-Correction** tab, click on the **Map Projection** and set as Projection: **UTM / WGS84 (Automatic)**.

Click **OK**. At the “Map Projection” you will see: UTM Zone 36, South / World Geodetic System 1984.



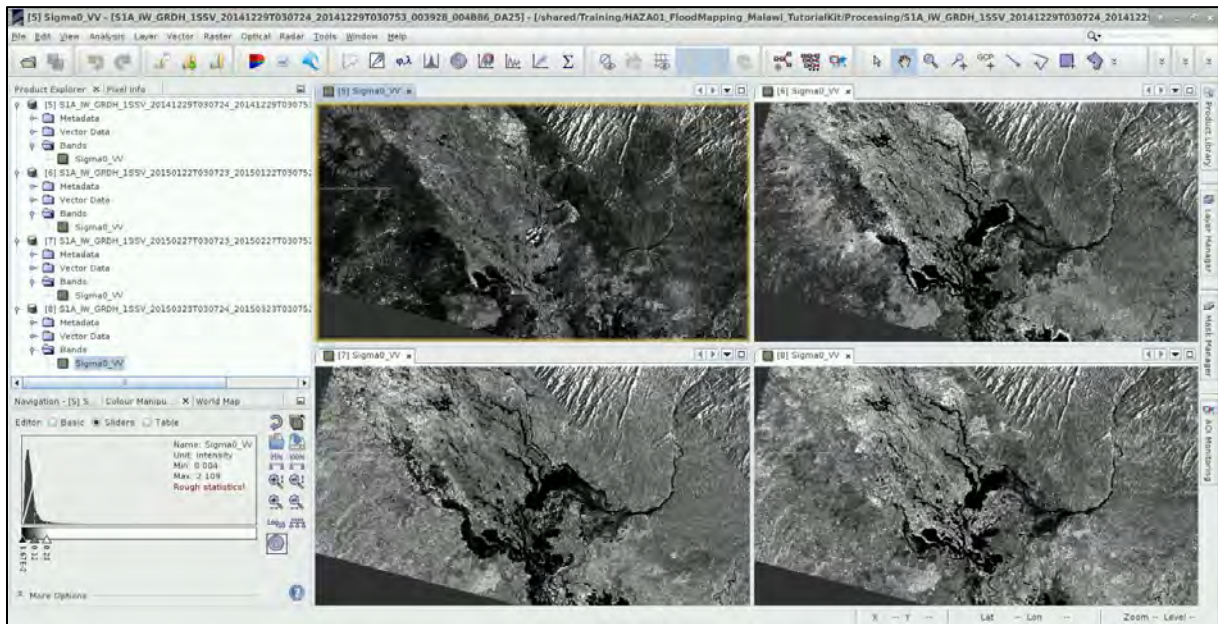
Leave all the other default settings and click **Run** to pre-process our images. *Approximate processing time: 5 minutes*


Now you should have four new products in the **Product Explorer**. Select the original products [1-4], right-click and click **Close 4 Products** (Click **No** if asked to save).


5.4 Binarization

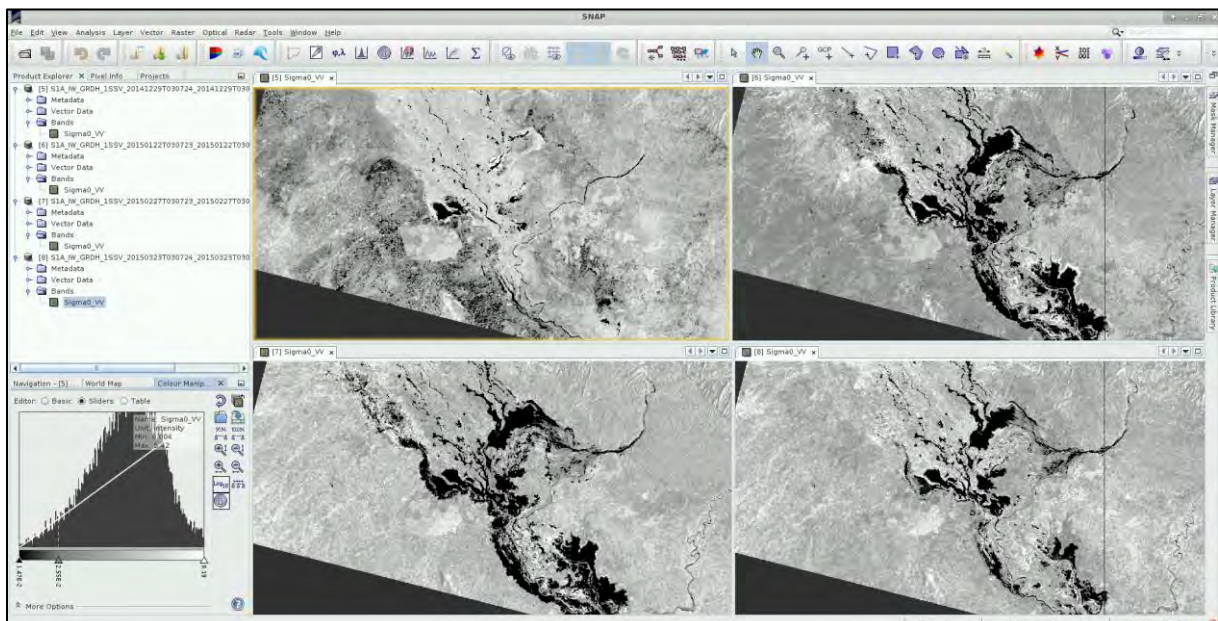
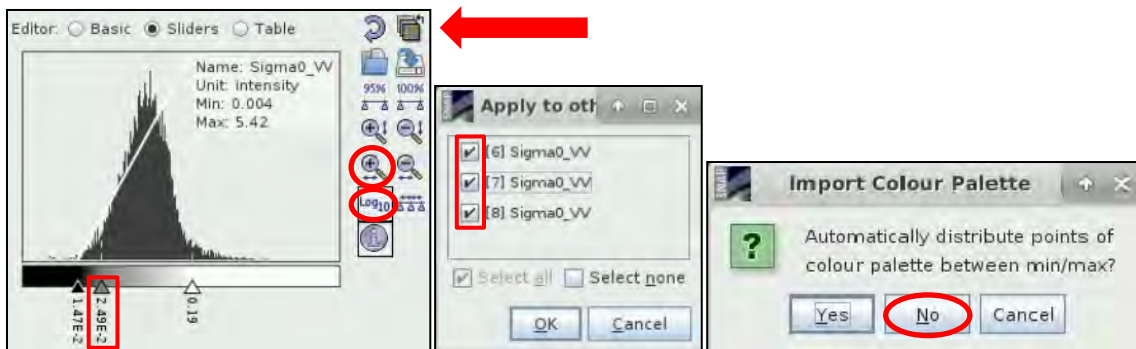
To separate water from non-water a threshold can be selected for each image. For this, we will analyze the histogram of the filtered backscatter coefficient. Low values of the backscatter will correspond to the water, and high values will correspond to the non-water class.

Open the **Sigma0_VV** band from all four created products [5-8] in the View and then go to **Window** → **Tile Evenly**. Click on the view [5] Sigma0_VV to activate it (a yellow boundary appears around it).



Then go to the left side panel, select the **Color Manipulation** tab and click once at the  (Stretch the histogram horizontally) on the left side of the tab.

Then move the middle slider below on the histogram to approx. ~ 0.025 and click on **Log₁₀**. Now we can see the water bodies better. Let's apply the same histogram stretch to other three images. To do this click on  and select all three bands and click **OK**. In next dialog click **No** (for each band).



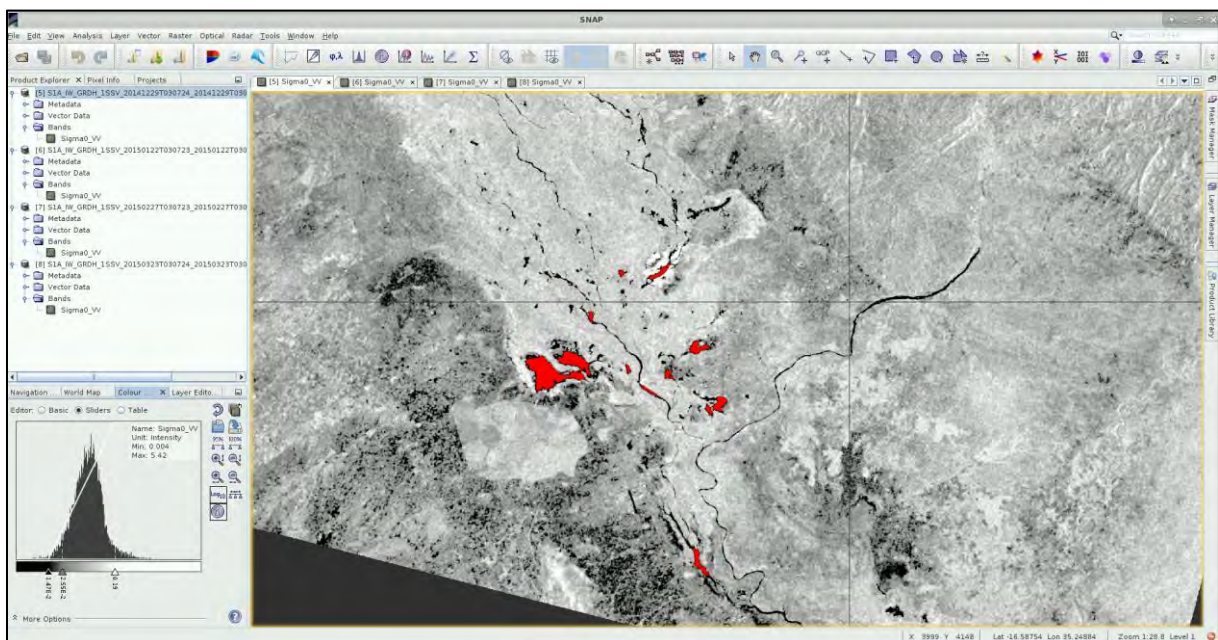
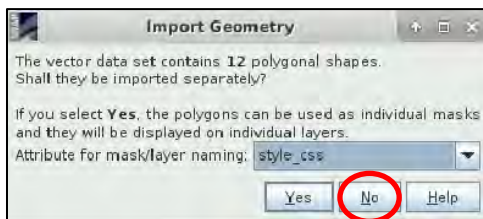
To create a binary mask of water and non-water pixels we create a new band and apply a conditional expression based on our threshold. To obtain our threshold value we will check the values occurring over the open water.

Go to **Window** → **Tile Single**. Go to View [5] Sigma0_VV.

You can create your own water body mask, but for this tutorial we will use one that has been prepared in advance and saved in the *Auxdata* folder. We can import it by clicking on the Product [5] in **Product Explorer** and then going to **Vector** → **Import** → **ESRI Shapefile**.

Navigate to */shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Auxdata* and open the shapefile *Water_ROI_Polygon.shp*.

Click **No** in the **Import Geometry** dialog (import all features into single mask).



Now let's have a look at the statistics.

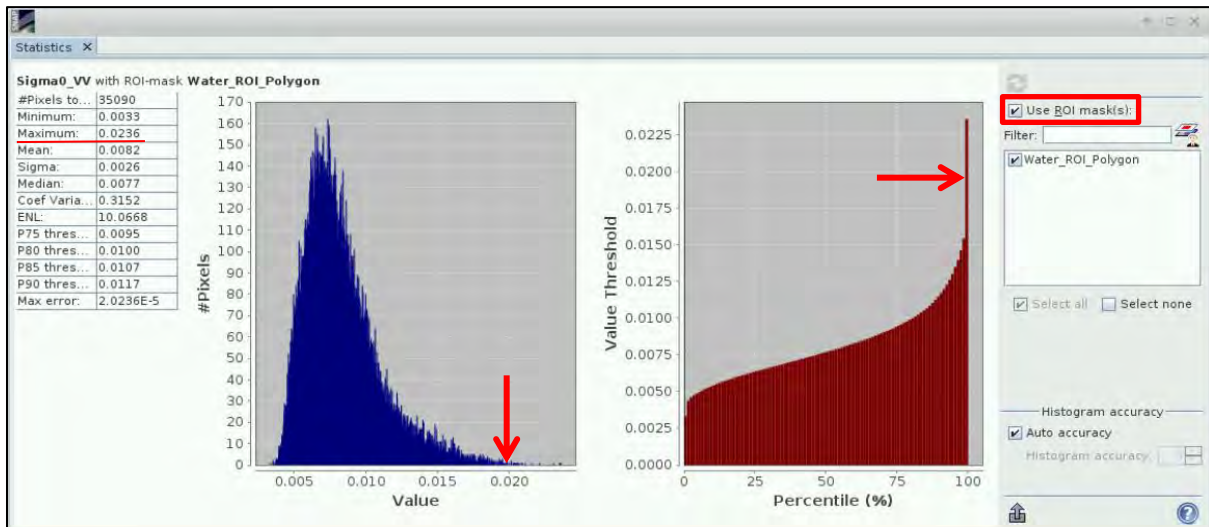
In the **Product Explorer** window, expand the bands folder in product [5] and click on band *Sigma0_VV* so it is highlighted.

Then go to **Analysis** → **Statistics**.

A new window will appear. On the right side select ✓ the "Use ROI Mask(s)", select the *Water_ROI_Polygon* (See 💡 TIP 1) and click 🔄 **Refresh**.



TIP 1: If the ROI/geometry does not appear in the window go to **Product Explorer**, expand the **Vector Data** folder in product [5] and click on *Water_ROI_Polygon*. Now it should appear in the statistics window as well and you can select it.



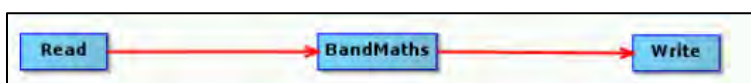
Now we can investigate the statistics. We can see that the maximum value in our Water polygons is 0.0236, the statistics also produces 90% percentile which gives a value of 0.0117. For our purposes we will adopt a value close to the 99% percentile which is not provided but can be estimated from the histograms. Let's choose 0.020 as our threshold (the statistics is of course always dependent on the ROI you choose and therefore can vary significantly). Now that we have the value of our threshold, we can close this window.

Here we assume that our polygons cover only pure water pixels and are not contaminated by any mixed coastal pixels or objects in the water (ships), therefore, we conclude that all the values smaller than our maximum value will correspond to water as well. We are still considering 1% of potentially contaminated pixels when choosing the 99% percentile. We could be more conservative to avoid misclassification (choose lower value), but threshold selection always requires some testing.

Now let's apply the threshold. We will apply the same threshold to all our images, therefore we can use the **Batch processing** again.

Firstly, let's build a very simple graph. Go to **Tools** → **Graph Builder**.


Add the **Band Math** operator (right-click on the white space and go to **Raster** → **Band Maths**) and connect the operators as shown below. At the bottom of the window **Save** the graph to the */shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Processing/Bin* folder with the name: **Graph_binary.xml**.

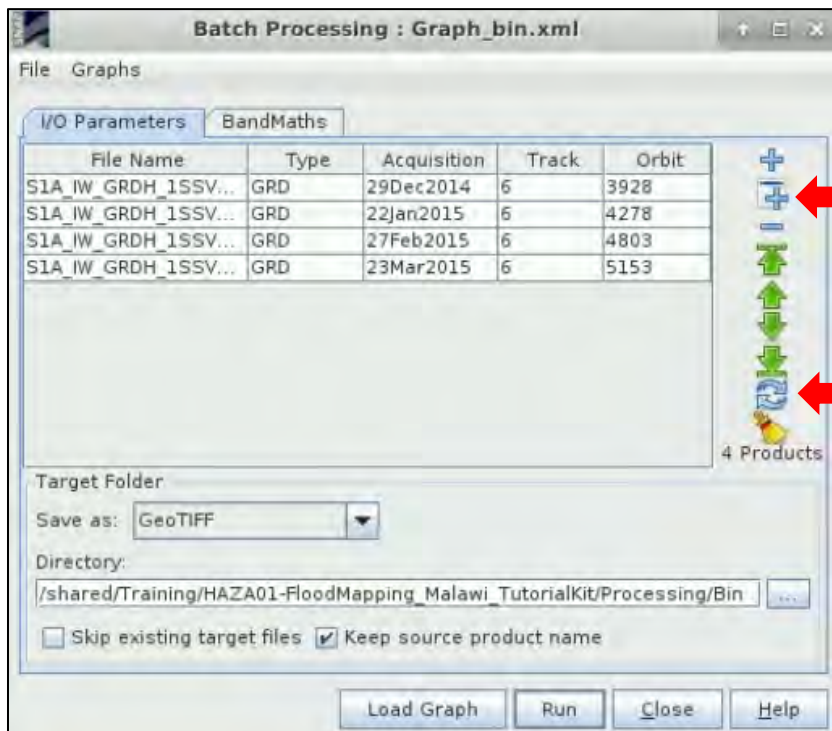


Close the **Graph Builder**.

Then go to **Tools** → **Batch Processing** and click **Add Opened** on the upper right (second icon from the top) and click **Refresh**. Click on the **Load Graph** button, navigate to our saved graph and open it. We can now see that the **Band Maths** tab has appeared at the top of window.

In the **I/O Parameters** tab, under the *Target Folder*, make sure that:

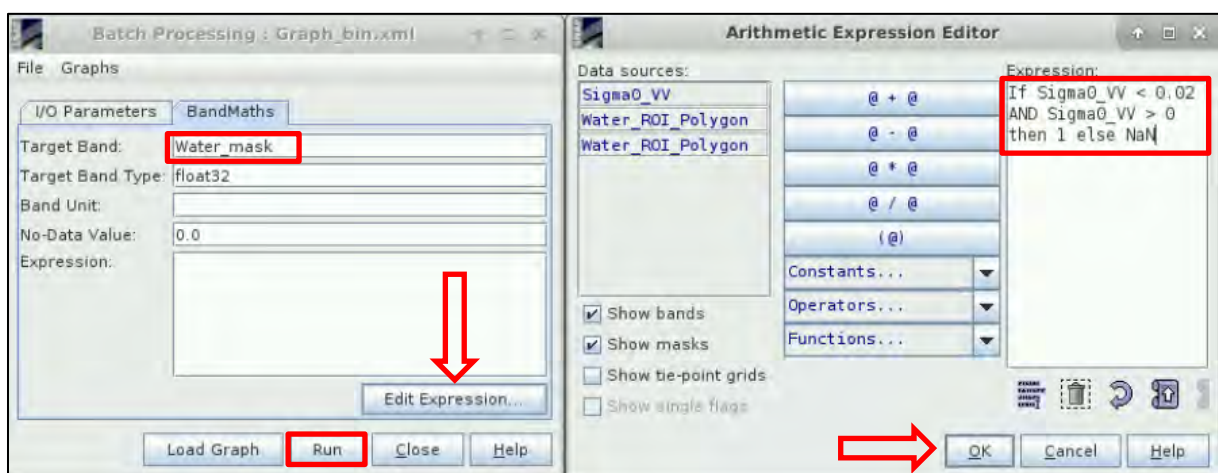
- the format (Save as) is set to **GeoTIFF**,
- the directory is: */shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Processing/Bin*
- and the "Keep source product name" option is selected (See  NOTE 6 - Page 14).



In the **BandMaths** tab, rename the new band to *Water_mask*, open the “**Edit Expression...**” and enter the following expression:

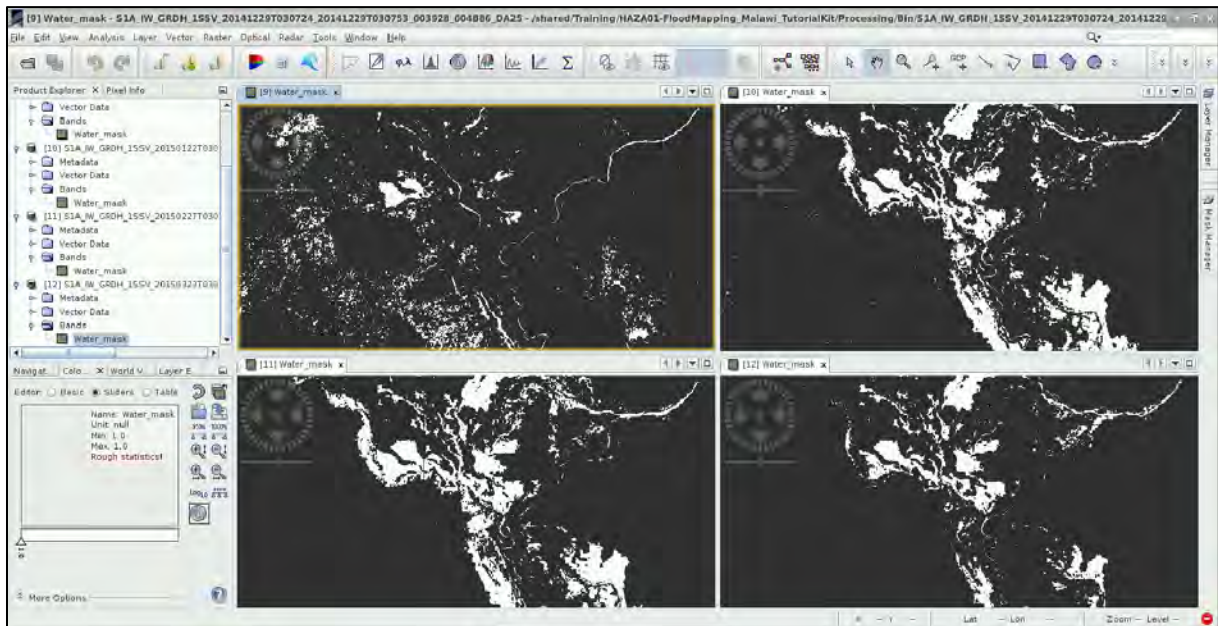
If $\text{Sigma0_VV} < 0.02$ AND $\text{Sigma0_VV} > 0$ then 1 else NaN

If no errors are found, click **OK** to close the Arithmetic Expression Editor and then click **Run**. After the processing is completed, close the Batch Processing window.

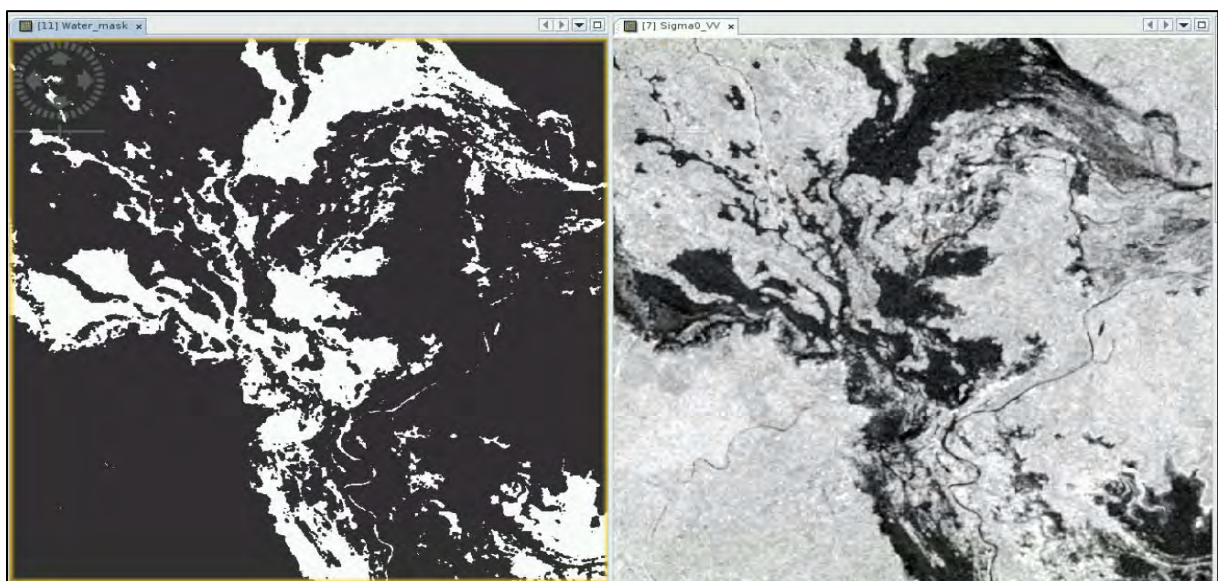


Four new products [9-12] have appeared in the **Product Explorer**. Close all opened view windows and open the **Water_mask** band for all the new products.

Go to **Window** → **Tile Evenly** in order to see all products at the same time.



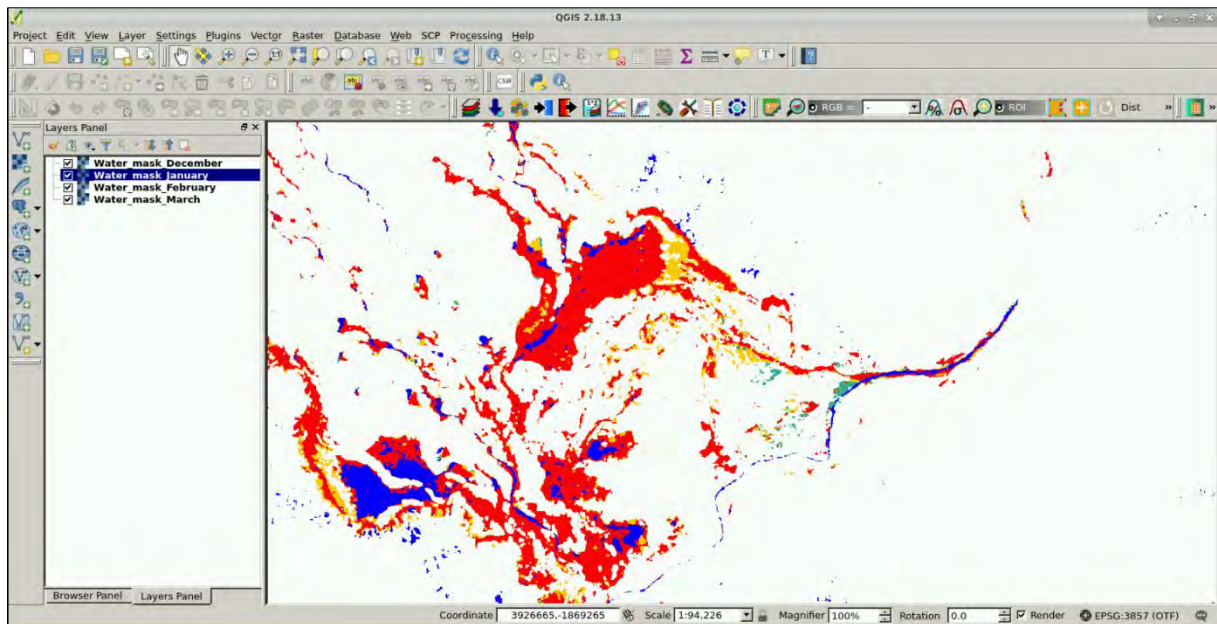
You can also compare the **Sigma0_VV** band to the **Water_mask** band of every product (29 December 2014).



Now we can close SNAP. To better visualize the output of our multi-temporal flood analysis, we will open the saved masks (GeoTIFF) in QGIS.

5.5 Visualization (QGIS)

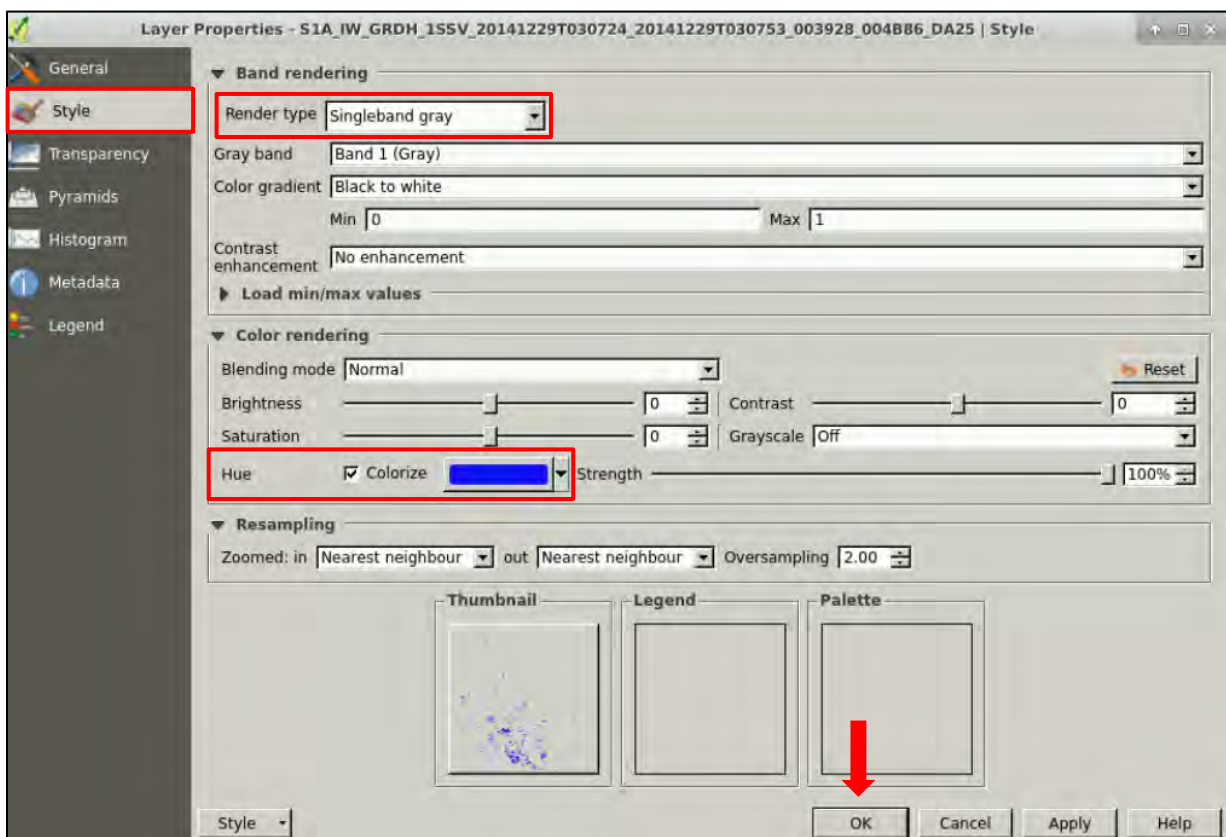
Open QGIS from the desktop shortcut or go to **Application → Processing → QGIS Desktop**. Click on the **Add Raster Layer** button located in the left panel (📁), navigate to: **/shared/Training/HAZA01_FloodMapping_Malawi_TutorialKit/Processing/Bin** select the four water masks and click **Open**.




You can change the style of each layer in the **Properties** menu. Right-click on the product you want to change and select **Properties**.

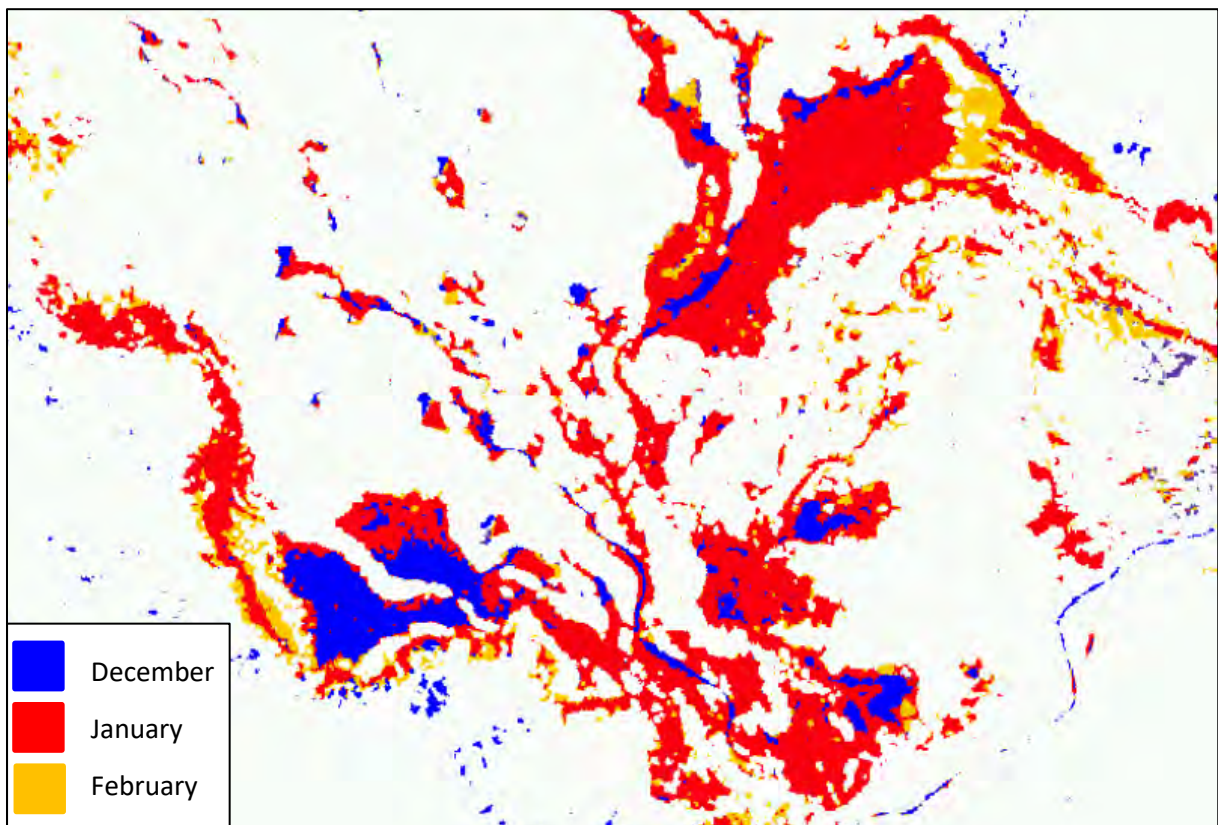
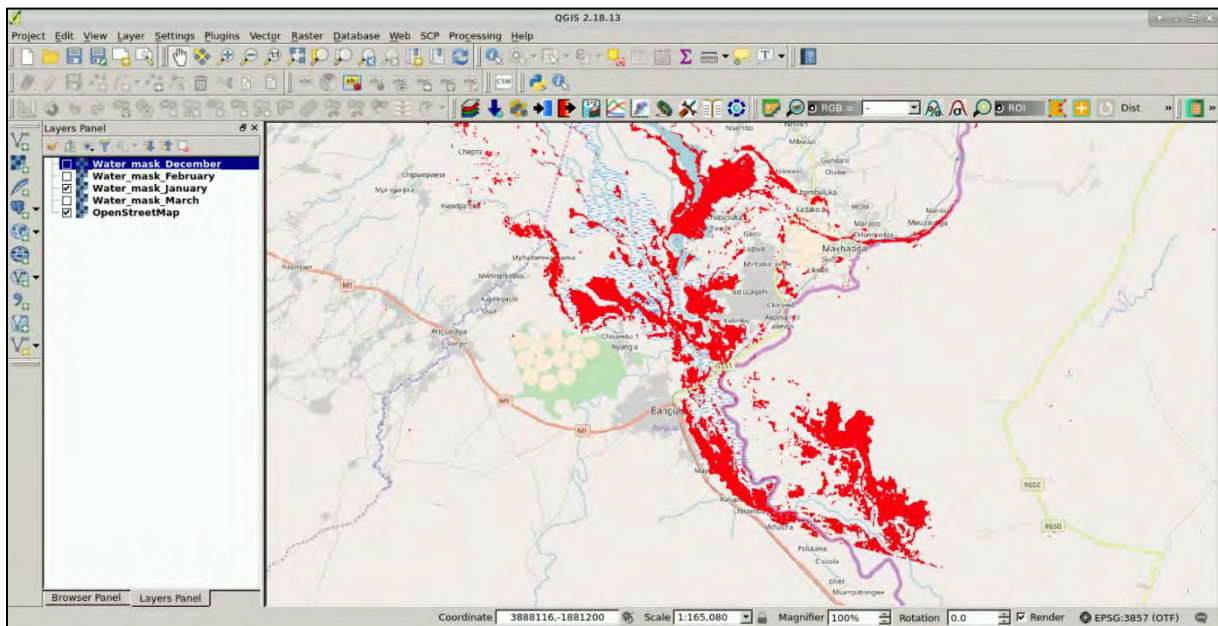
In the **Style** tab, under Band Rendering select “**Singleband gray**” as **Render type**.

In the **Color Rendering** section, activate the **Colorize** option, select a color and click **OK**.



Finally, we can add a base-map to link our water masks to GIS data. Click on **Web** → **OpenLayers** plugin → **OpenStreetMap** → **OpenStreetMap** (See  NOTE 8).

NOTE 8: 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. Select the plugin on the list and click “Install Plugin”. Restart QGIS to finalize the installation.



THANK YOU FOR FOLLOWING THE EXERCISE!

6 Further reading and resources

Irimescu, A., Gh Stancalie, V. Craciunescu, C. Flueraru, and E. Anderson. "The Use of Remote Sensing and Gis Techniques in Flood Monitoring and Damage Assessment: A Study Case in Romania." In *Threats to Global Water Security*, 167–77. NATO Science for Peace and Security Series C: Environmental Security. Springer, Dordrecht, 2009. doi:10.1007/978-90-481-2344-5_18.

Fayne, J., Bolten, J., Lakshmi, V., & Ahamed, A. (2017). Optical and Physical Methods for Mapping Flooding with Satellite Imagery. In *Remote Sensing of Hydrological Extremes* (pp. 83–103). Springer, Cham. https://doi.org/10.1007/978-3-319-43744-6_5

FOLLOW US!!!



[@RUS-Copernicus](https://twitter.com/RUS-Copernicus)



[RUS-Copernicus](https://www.linkedin.com/company/rus-copernicus)



[RUS-Copernicus](https://www.facebook.com/RUS-Copernicus)



[RUS Copernicus Training](https://www.youtube.com/channel/UCv33333333333333333333)



[RUS-Copernicus website](https://www.rus-copernicus.eu)



[RUS-Copernicus Training website](https://www.rus-copernicus.eu/training)