

## TRAINING KIT - OCEA01

SHIP DETECTION WITH SENTINEL-1 USING SNAP S-1  
TOOLBOX - GULF OF TRIESTE, ITALY



Research and User Support for Sentinel Core Products

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

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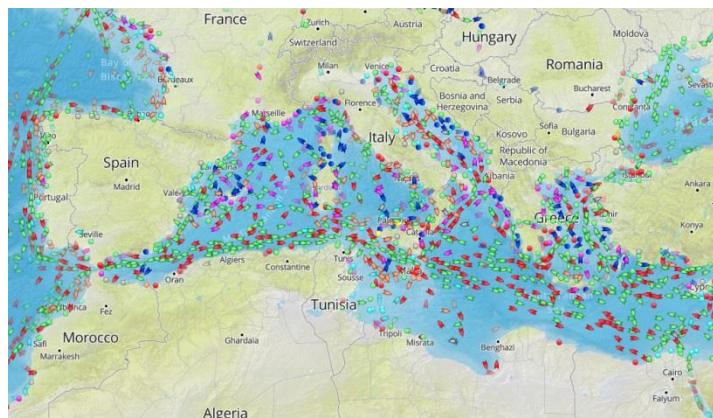
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## 1 Introduction

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.



AIS real time marine traffic – 27 Jun. 2017 3:27 PM

In this tutorial we will employ RUS for ship detection (marine surveillance) in the Gulf of Trieste using Sentinel-1 Satellite-borne synthetic aperture radar (SAR). Marine surveillance can be done using different methodologies. A first option consists of cooperative systems in which ships themselves report their identities and positions. The three most common options are Automatic Identification System (AIS), Long Range Identification and Tracking

(LRIT) and Vessel Monitoring System (VMS). While the first one is in fact available continuously and globally, the two others are not. Another option is the non-cooperative systems which do not require cooperation on the side of the vessel. These systems most commonly use cameras and radars located on a variety of platforms (ship, airplanes, satellites, etc.).

Ship detection with Sentinel-1 falls into the non-cooperative category and enables detection of vessels not carrying AIS or other tracking system on board such as smaller fishing ships or ships that are in the surveyed area illegally (illegal fishing, piracy etc.). Moreover, SAR is not reliant on solar illumination and is rather independent of weather conditions, therefore enabling frequent monitoring.

## 2 Training

Approximate duration of this training session is one hour.

**The Training Code for this tutorial is OCEA01. 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

- One Sentinel-1A IW GRDH images with VH & VV polarization acquired on 9 October 2016 [downloadable @ <https://scihub.copernicus.eu/>]  
*S1A\_IW\_GRDH\_1SDV\_20161009T165807\_20161009T165832\_013416\_0156B9\_4550.zip*
- Vector Sea mask as ESRI Shapefile stored in:  
*/shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Auxdata*

### 2.2 Software in RUS environment

Internet browser, SNAP + Sentinel-1 Toolbox, QGIS (Extra steps: Google Earth Web)

### 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](http://www.rus-copernicus.eu)) and click on *Login/Register* in the upper right corner.

The screenshot shows the RUS homepage. At the top, there's a blue header with the RUS logo, the text "Research and User Support", and several small icons representing different types of data or services. On the far right of the header, there's a red box highlighting the "Login / Register" button. Below the header, there's a navigation menu with dropdowns for "The RUS Service", "The RUS Offer", "The RUS Library", and "The RUS Community". The main content area has a large satellite image of a coastal city. To the right of the image is a search bar with a magnifying glass icon. Below the search bar is a section titled "News from RUS" with a list of events like "Copernicus Info Session – Reykjavik – 19 September 2018" and "SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12 September 2018". Further down is another section titled "The RUS agenda" with a link to "Conferences & Workshops".

Select the option *Register Copernicus SSO account*. A pop-up message will appear informing you that during the second step of the registration process, and when you will be requested to complete your profile in the Copernicus Data Service Portal, you should select **Public** as user category in order to ease and speed up the registration process. Click Ok

The pop-up message is titled "Login / Register". It contains the following text:  
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.  
A red box highlights the "REGISTER COPERNICUS SSO account" button.  
Below the button, it says: "Users who already have a COPERNICUS SSO account can login here:" followed by a "Login" button.  
At the bottom left is a "Close" button, and at the bottom right is a red box highlighting the "OK" button.  
The right side of the pop-up has a "WARNING" section with the same text as the left side, followed by: "Persons willing to use a gmail account for registration shall check their Spam folder regularly. RUS emails tend to be filtered by Google." and another red box highlighting the "OK" button.

Then, fill in the fields on the Copernicus Users' Single Sign On Registration. Then click *Register*.

The screenshot shows the 'Copernicus Users' Single Sign On Registration' page. At the top, there's a logo for 'esa CDS-SSO' and a 'FAQ' link. Below the header is a dark blue bar with the title 'Copernicus Users' Single Sign On Registration'. The main area contains a 'Registration form' with various input fields: 'I'm already registered' (checkbox), 'CDS-SSO ID', 'Secret question' (dropdown menu), 'Answer', 'Password', 'Confirm password', 'Email', 'Confirm email', 'First name', 'Last name', 'Institution', and 'Country of residence' (dropdown menu). Below these fields is a CAPTCHA box containing 'dSafn' with a placeholder 'Type the characters'. A red box highlights the 'Register' button at the bottom of the form.

Once you click on the registration button, you will be requested to complete your profile in the Copernicus Data Service Portal. **WAIT UNTIL YOU ARE REDIRECTED**. This may take up to one minute. Make sure all your User Details are correct, set the company/institution details, select *Public* as user category and click *Submit*.

The screenshot shows the 'Copernicus user's personal area' with a 'User Registration Request' form. The left side lists 'User Details' including First Name, Last Name, Email, Username, Country, City, Postal Code, Address, Phone, and Mobile phone, all with grayed-out placeholder text. The right side shows 'Account Details' with a red box around the 'Company/Institution\*' field. Below it is a 'User Category' dropdown menu with options: Copernicus\_Services, INT\_ORG NGO, Public (which is selected and highlighted in blue), and Public\_Auth. A red arrow points to the 'Public' option. At the bottom right are 'Clear' and 'Submit' buttons, with a red box highlighting the 'Submit' button.

Your Copernicus SSO account must be validated by an operator. You will then receive an e-mail with activation link. Follow the instructions in the e-mail to activate your account and log-in.

Once you receive the third email, you will be able to Login. You can now return to <https://rus-copernicus.eu/>, click on Login/Register, choose Login and enter your chosen credentials.

## 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*.

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.

**User Support Request**

Step 1/3 Your experience

Please help us learn more about your background by answering a few questions. This information will be stored in your User Profile.

How many years of experience in Remote Sensing do you have?  
Choose one item...

Have you already downloaded Copernicus data via the Copernicus Open access hubs?  
 Yes  
 No

Have you already handled/processed Copernicus data?  
 Yes  
 No

Do you wish to practice a tutorial exercise shown in a RUS webinar? If yes, please select your choice (hold down CTRL key for multiple selections).

- 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
- OCEA01 - Ship Detection in Gulf of Trieste

If you wish to request another tutorial exercise that doesn't appear in the above list, please type here its name or code. Note that you can request multiple tutorial exercises.

**Cancel** **Next**

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	GRD
S1 - Sensor mode	-
S1 - Polarisation	-
S1 - Orbit direction	-
<i>Sentinel-2</i>	X
<i>Sentinel-3</i>	X
<i>Other</i>	X
<i>I don't know</i>	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*.

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

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

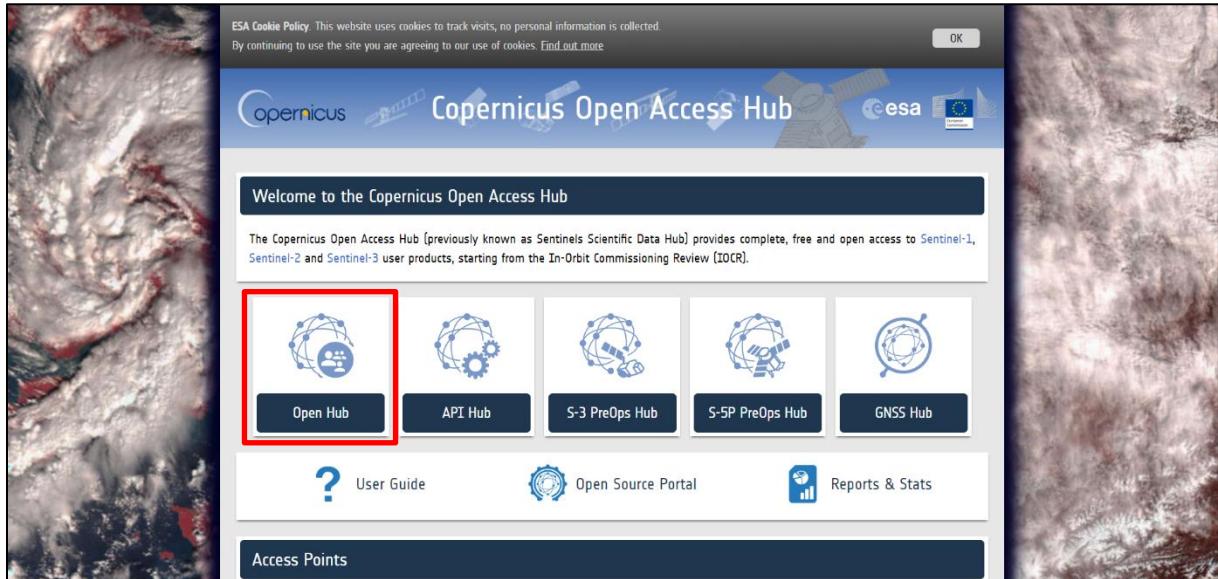


## 5 Step by step

### 5.1 Data download – ESA SciHUB

In this step we will download a Sentinel-1 scene from the Copernicus Open Access Hub using the online interface.

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

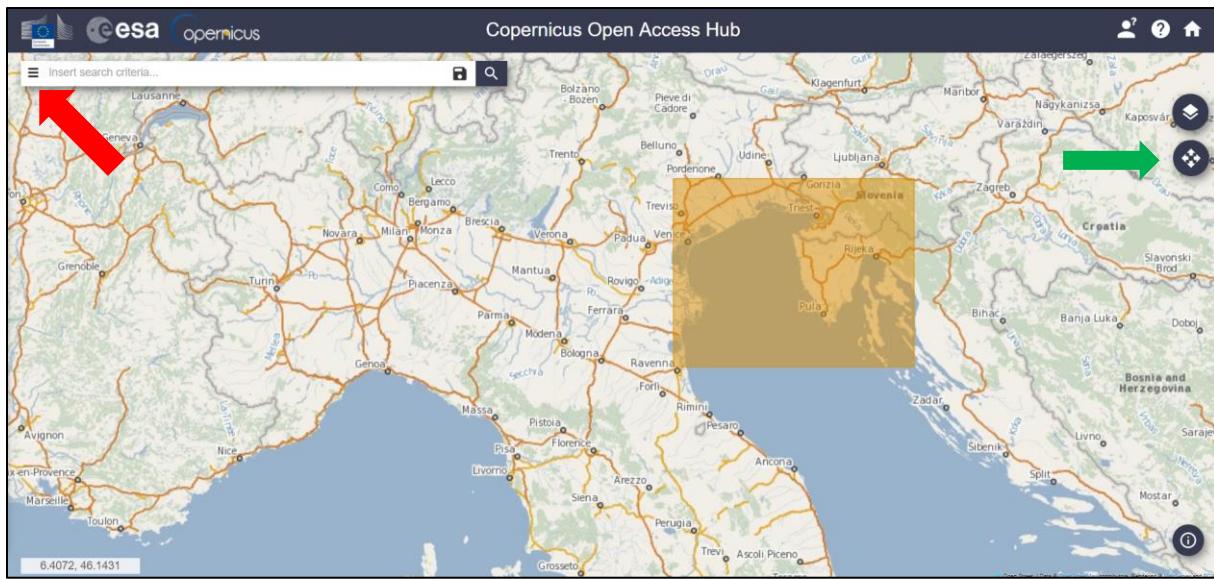


Go to Open HUB, if you do not have an account please register by going to “sign-up” in the LOGIN menu in the upper right corner.



After you've 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, log in.

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



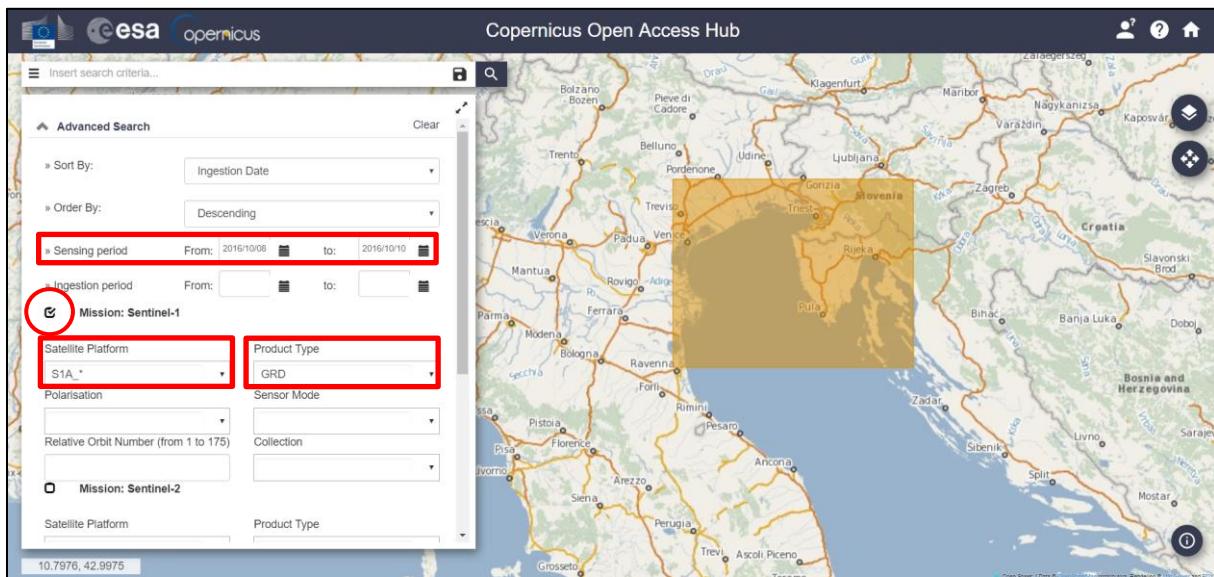
Open the search menu by clicking to the left part of the search bar and specify the following parameters:

**Sensing period:** From 2016/10/08 to 2016/10/10

**Check Mission:** Sentinel-1

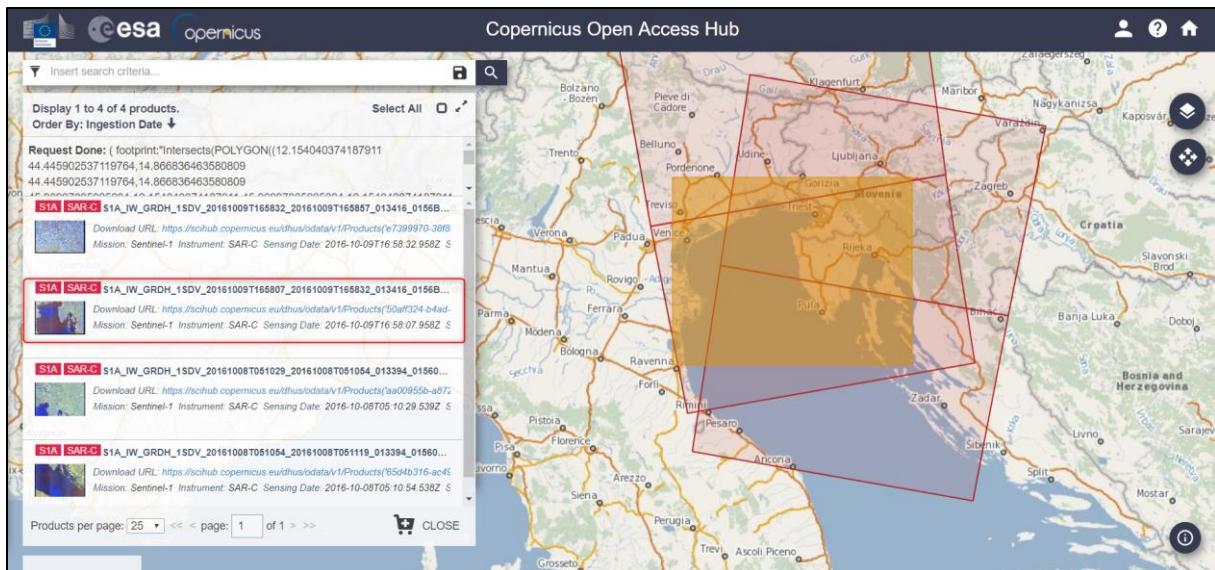
**Satellite Platform:** S1A\*

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



In our case, the search returns approximately 4 results depending on the exact search area defined.

Download scene [S1A\\_IW\\_GRDH\\_1SDV\\_20161009T165807\\_20161009T165832\\_013416\\_0156B9\\_4550](#).



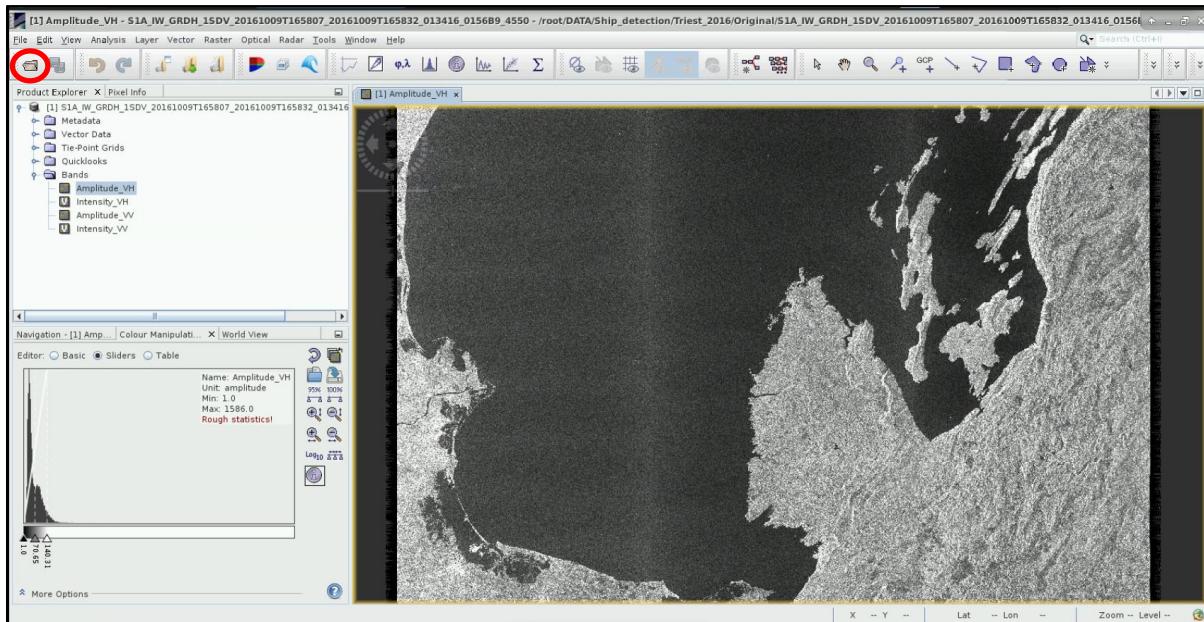
Move downloaded scenes from the *Downloads* folder (*/home/rus/Downloads*) to:  
*/shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Original*

## 5.2 SNAP - open and explore data

Open **SNAP Desktop** (icon located on the desktop); click **Open product** , navigate to:  
*/shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Original*  
and open *S1A\_IW\_GRDH\_1SDV\_20161009T165807\_20161009T165832\_013416\_0156B9\_4550.zip*

The opened product will appear in **Product Explorer**. Click + to expand the contents of the file, then expand Bands and double click *Amplitude\_VH* to visualize the band.

We can see that the view appears “upside down”: this is because the scene was acquired during **ascending** pass (the satellite was moving in south to north direction looking to the east) and the view shows the pixels in order of data acquisition as the image is not yet projected into cartographic coordinates.

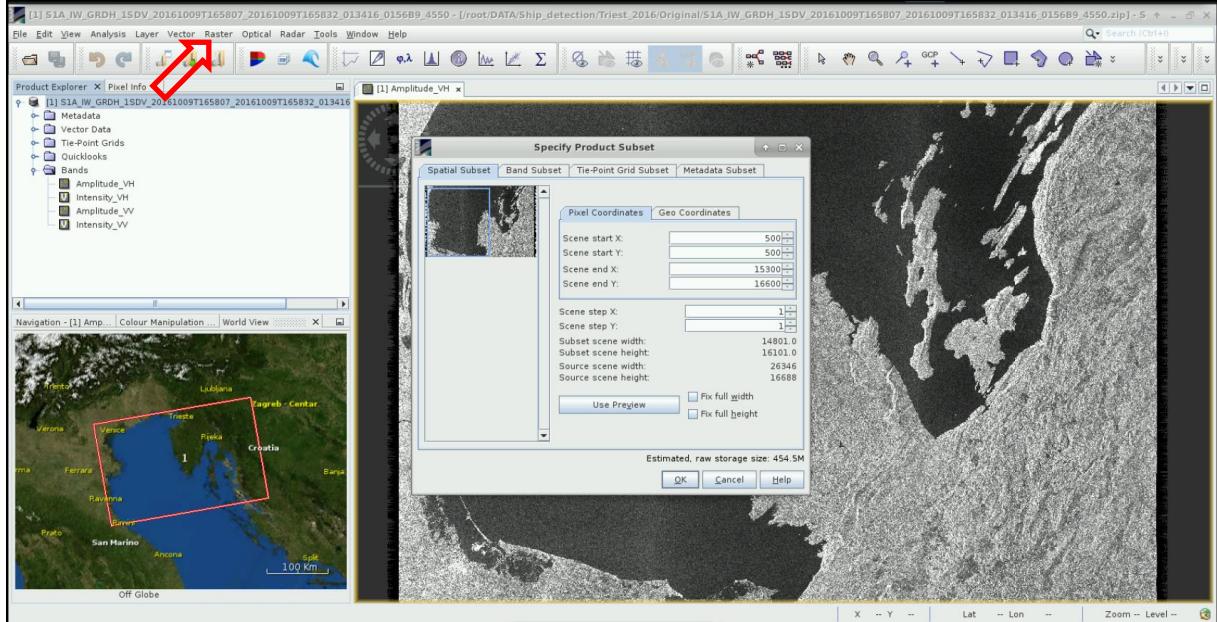


### 5.3 Subset

Since our Area of Interest (AOI) is quite small and there is no need to process the whole image, we start with sub-setting the scene to a more manageable size (See NOTE 1). This will reduce the processing time in further steps and is recommended when the analysis is focused only over a specific area and not the complete scene.

NOTE 1: the subset product appears in the **Product Explorer** but is not physically saved.

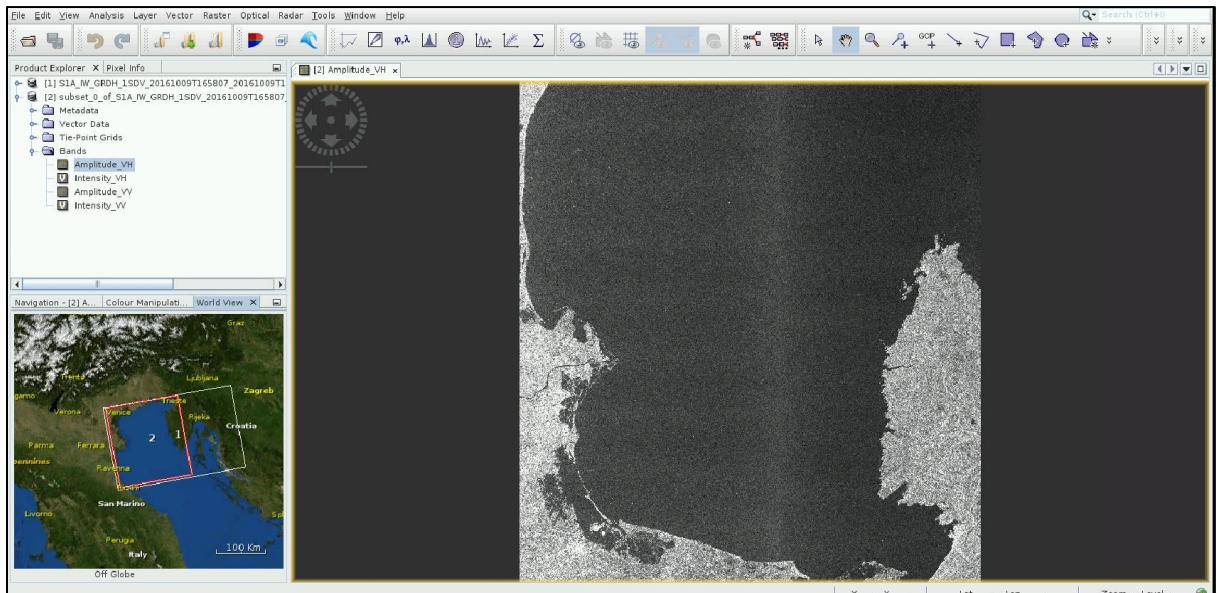
Click Raster -> Subset.



In the subset menu set the extent of the AOI in pixel coordinates to:

Scene start X: **500**      Scene start Y: **500**      Scene end X: **15300**      Scene end Y: **16600**

Click OK. A new product has appeared in **Product Explorer**. Expand the products structure go to Bands and double-click the *Amplitude\_HV* to open it in View.

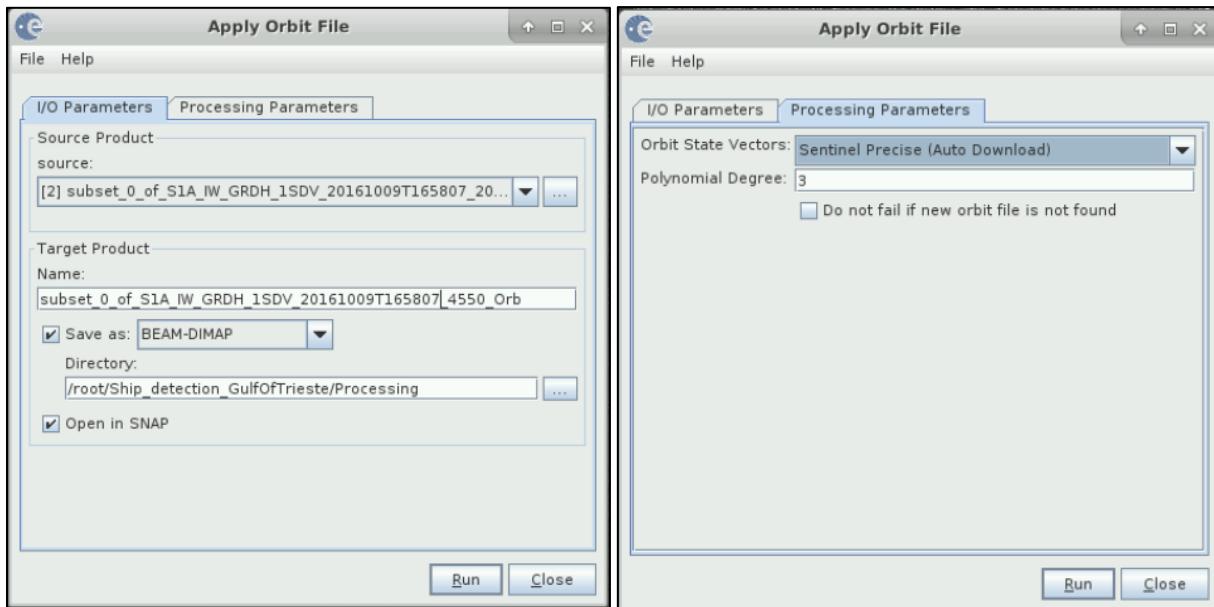


## 5.4 Apply orbit file

Next, we will apply precise orbit to the subset. (See  NOTE 2)

 NOTE 2: 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)

### Click Radar -> Apply Orbit file



We can shorten the output name a bit to:

*subset\_S1A\_IW\_GRDH\_1SDV\_20161009T165807\_4550\_Orb*

and set output folder to:

*/shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Processing*

Use this folder to save all the following processing products. All other settings remain set to default values. Click **Run**. *Approximate processing time: 22sec*

## 5.5 Add vector mask

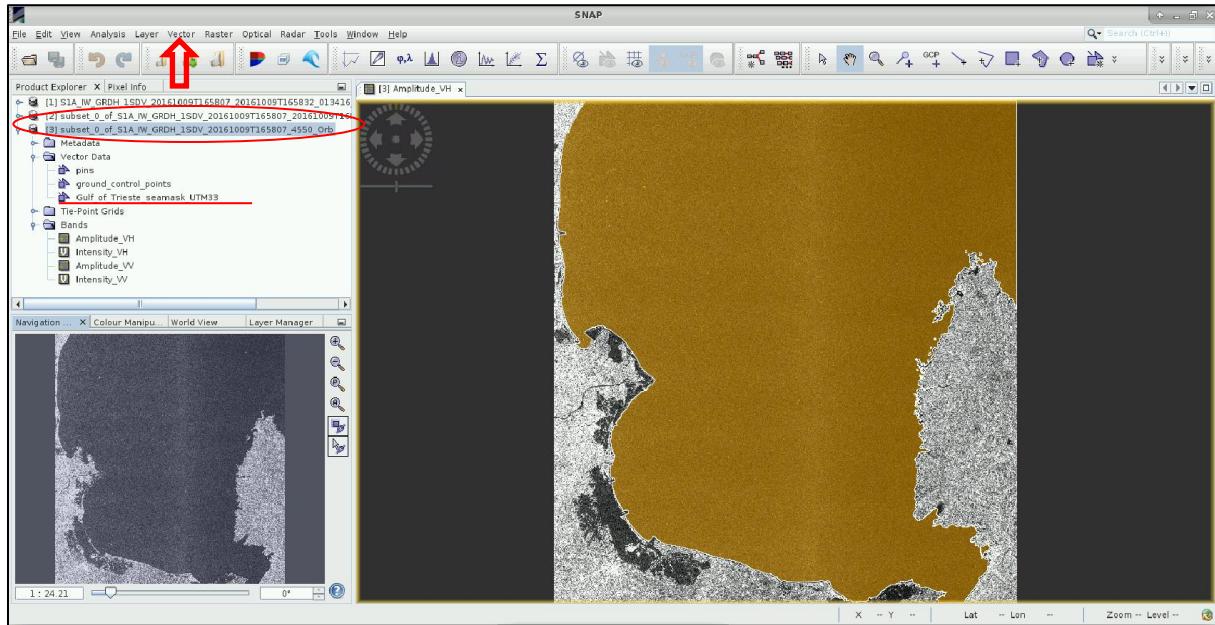
In order to avoid detection of false targets (ships) on land the SNAP Ocean Object detection includes a land masking function. By default the SRTM 3sec digital elevation model is used to identify and mask out areas with positive elevation. This method however can sometimes introduce false targets along complicated coastlines such as the Gulf of Trieste; therefore here we choose to use our own vector mask. To do this we first need to import the mask into our product.

Open the *Amplitude\_VH* band of the newly created product [3] and close all other views. Then select the *S1A\_IW\_GRDH\_1SDV\_20161009T165807\_4550\_Orb* by clicking on it (whole product, not single band).

### Click Vector -> Import -> ESRI Shapefile

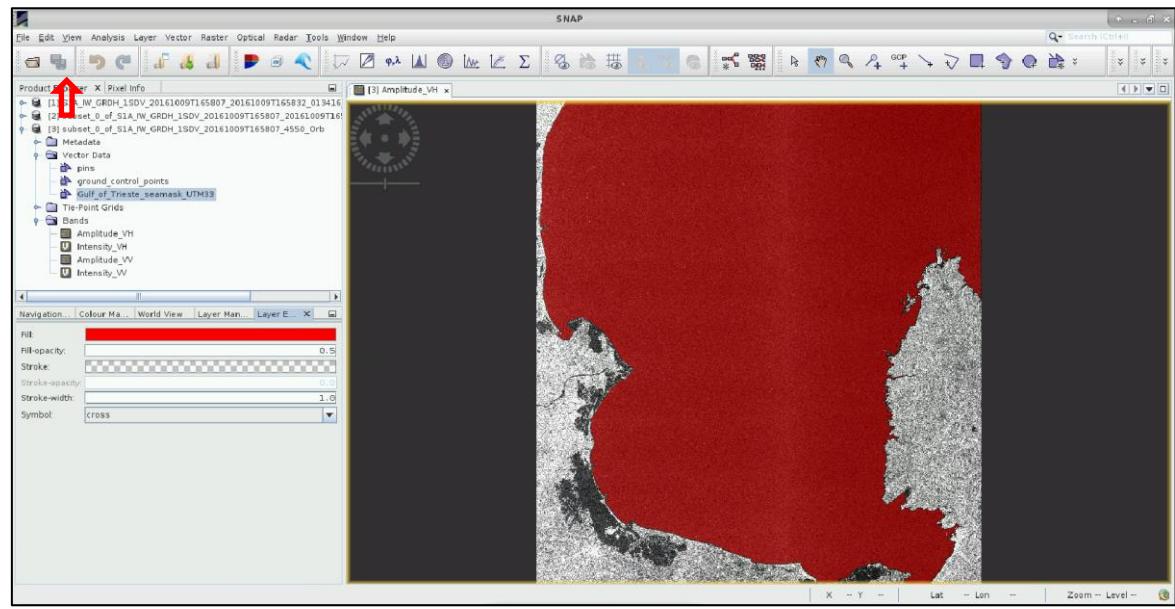
Navigate to: */shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Auxdata*

Open: *Gulf\_Of\_Trieste\_seamask\_UTM33.shp*



Now you can see a coloured overlay on top of your open product and a new vector layer added into you Vector Data folder in the product. (See TIP 1)

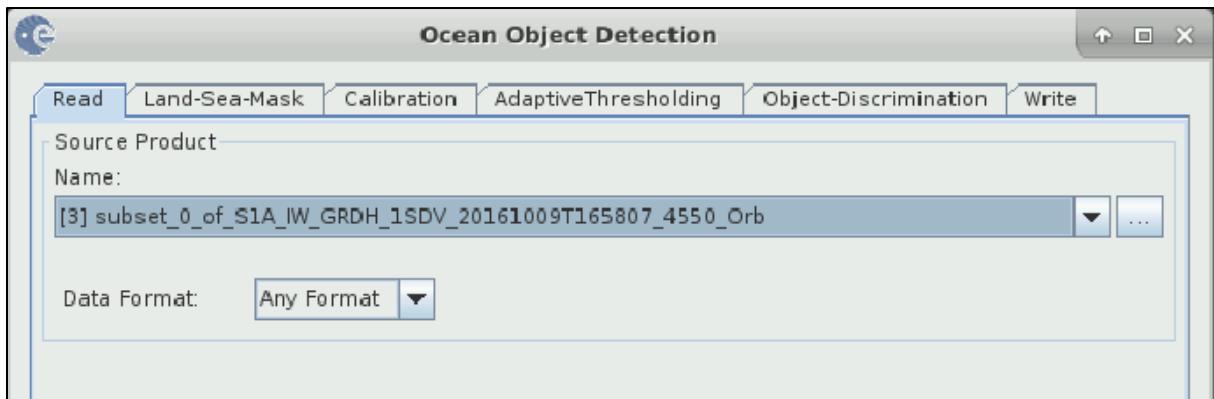
**TIP 1:** Visualization of the vector overlay: To change the appearance of the added vector layer we can go to **View -> Tools Manager -> Layer Manager**. A new pane will open and we can see all layers in our currently selected product. Expand the Vector data tab and select the *Gulf\_Of\_Trieste\_seamask\_UTM33* and click on Layer editor In Layer editor you can change the colour, transparency, outline width etc.



## 5.6 Run ship detection

Now we will run the ship detection algorithm. It consists of several steps: Land-Sea Mask, Calibration, Adaptive Thresholding and Object Discrimination. We will go through each step separately.

**Click Radar -> SAR Applications -> Ocean Applications -> Ocean Object Detection**

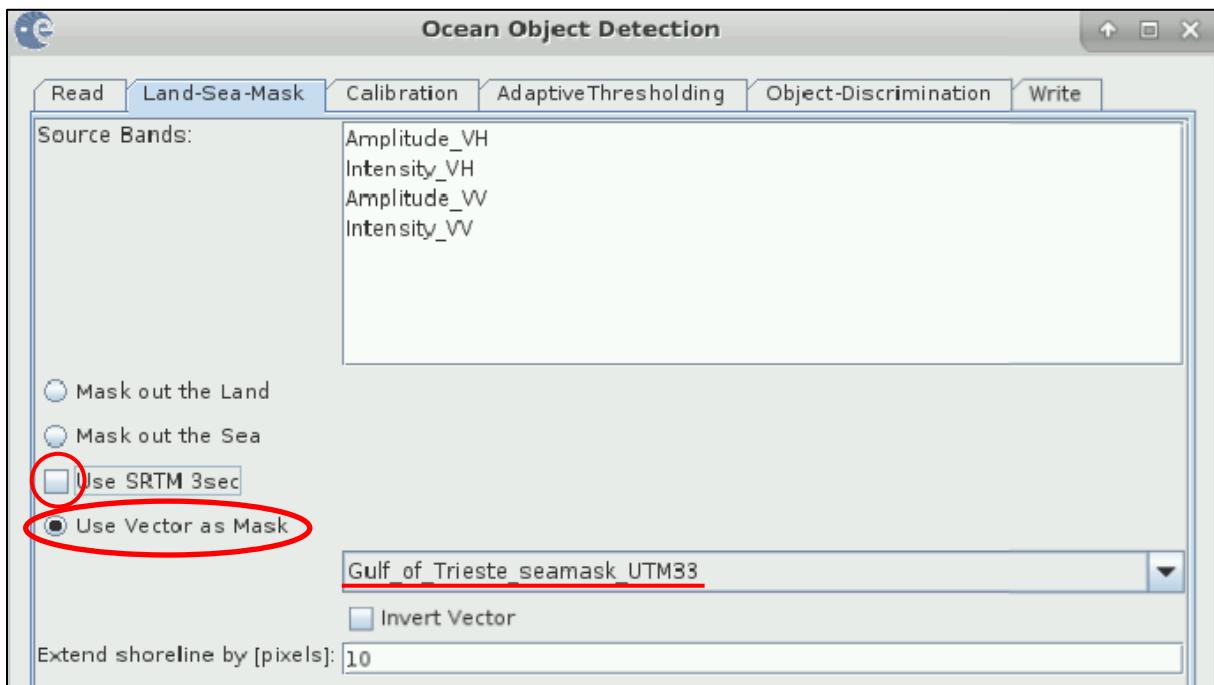


In the processing window we see all steps as tabs. In the Read tab set the subsetted product with updated orbit information as an input. ([3]S1A\_IW\_GRDH\_1SDV\_20161009T165807\_4550\_Orb)

#### 5.6.1 Land-Sea-Mask

The first step is masking the land areas to avoid false target detections on land (as discussed above). Here we will use loaded vector mask *Gulf\_Of\_Trieste\_seamask\_UTM33* and mask out areas that are not overlaid.

Unclick the Use SRTM 3 sec and select Use Vector as Mask. The loaded vector layer will appear in the text box. If no source band/s is/are selected, all bands will be used by default.

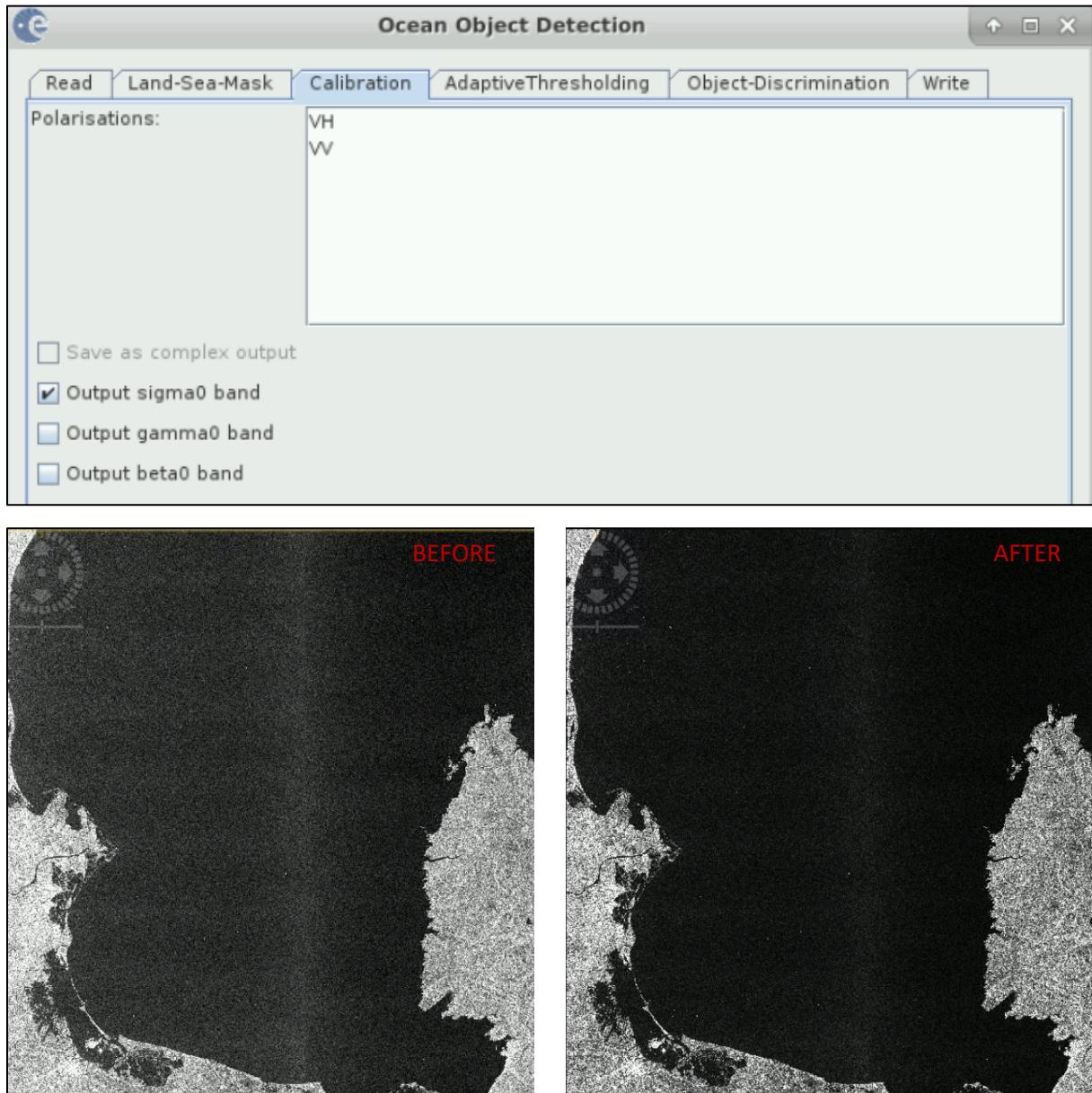


#### 5.6.2 Calibration

In the next step we will apply radiometric calibration. The objective of SAR calibration is to provide imagery in which the pixel values can be directly related to the radar backscatter of the scene. Though uncalibrated SAR imagery is sufficient for qualitative use, calibrated SAR images are essential to quantitative use of SAR data. (See NOTE 3)

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)

Keep the all default settings.



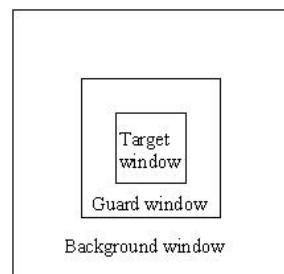
On the image above we can see the effect of radiometric correction.

### 5.6.3 Adaptive Thresholding

Adaptive thresholding is a frequently used method for target detection in SAR imagery. The underlying assumption is that targets appear bright on dark background. The adaptive thresholding algorithm is applied in moving window. For each pixel under test (central pixel) a new threshold

value is calculated based on the statistical characteristics of its local background: if the pixel value is above the threshold the pixel is classified as target pixel (for more info see  NOTE 4).

 **NOTE 4:** The specific type of adaptive thresholding algorithm used in the SNAP Ocean Object Detection tool is a Two-Parameter Constant False Alarm Rate (CFAR) Detector. The user defines the parameters of the moving window (image on the right) where the Target window corresponds to one or multiple pixels under test; the Guard window prevents contamination of the background values by the target pixels; the values within the Background window represent the local background and are used to determine the probability distribution function (PDF) of fitted Gaussian distribution.



Credits: SNAP Help

Then the PDF and user defined probability of false alarm (*PFA*) are used to determine the detection design parameter *t* as follows:

$$PFA = \frac{1}{2} - \frac{1}{2} \operatorname{erf}\left(\frac{t}{\sqrt{2}}\right)$$

The decision criterion is then expressed as:  $x_t > \mu_b + \sigma_b \Leftrightarrow \text{target}$  (target window is single pixel) or as:  $\mu_t > \mu_b + \sigma_b \Leftrightarrow \text{target}$  (target window contains multiple pixels), where  $x_t$  is value of target pixel or  $\mu_t$  is mean value of target window;  $\mu_b$  is background mean and  $\sigma_b$  is background standard deviation.

(SNAP Help)

Specify the following parameters:

**Target Window Size (m):** 30 (the target window size in metres; length of smallest target to detect, See  TIP 2)

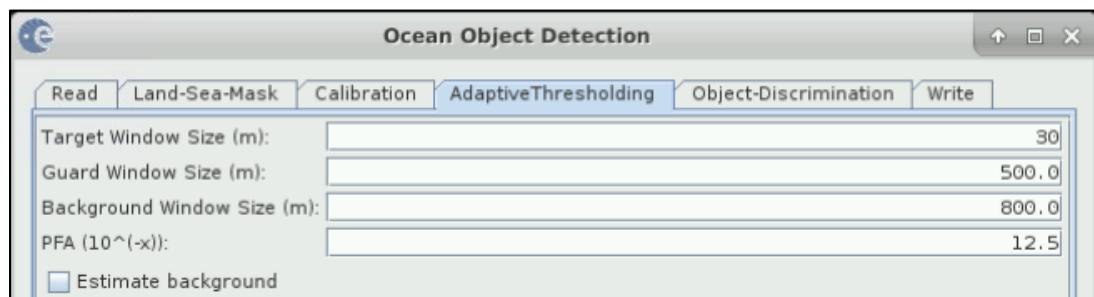
**Guard Window Size (m):** 500 (the guard window size in metres; size of the largest target to detect)

**Background Window Size (m):** 800 (the background window size in metres; larger than the guard window size to ensure accurate calculation of the background statistics)

**PFA (10<sup>-x</sup>):** 12.5 (positive number for parameter x)



TIP 2: The size of the smallest detectable object is dependent on the data resolution. The Sentinel-1 IW GRDH Product that we are using here has a resolution of 20x22 metres (but pixel spacing 10x10 metres). Therefore, to avoid excessive numbers of false targets we set the smallest detectable target to 30 m, value larger than the spatial resolution.

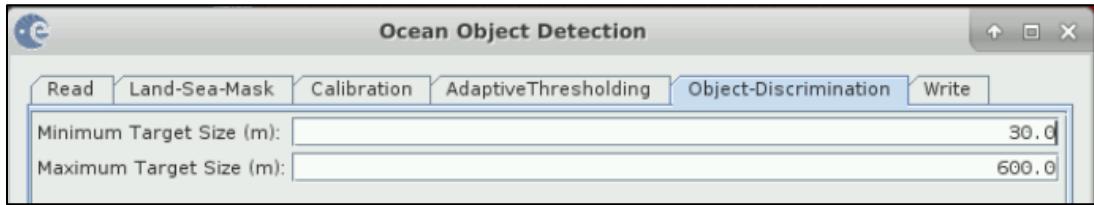


#### 5.6.4 Object Discrimination

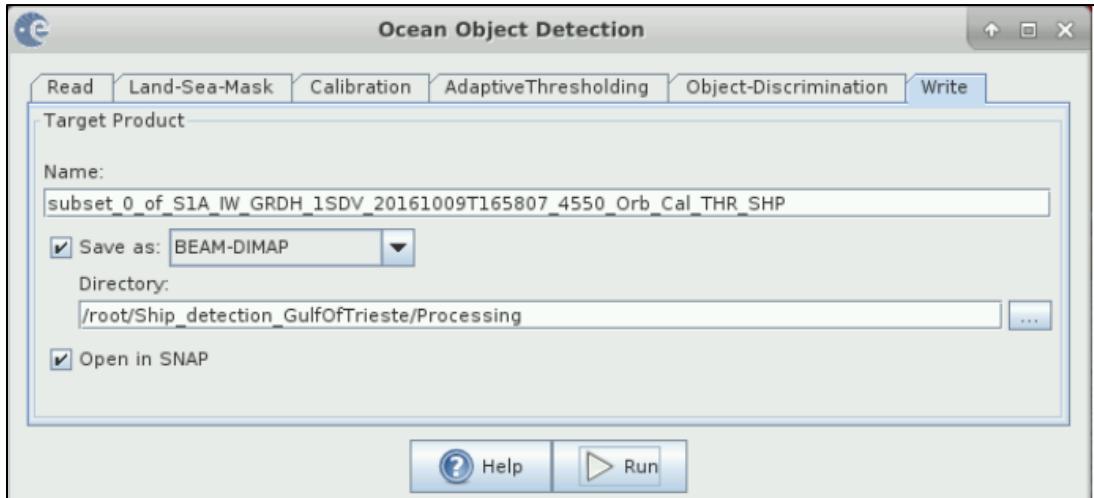
This step is used to filter out false targets based on minimum and maximum size limits. Set the following parameters:

**Minimum Target Size (m):** 30 (target with dimension smaller than this threshold is eliminated)

**Maximum Target Size (m):** 600 (target with dimension larger than this threshold is eliminated)



In the last tab of the processor we set the location of the product to our ‘Processing’ folder (`/shared/Training/OCEA01_ShipDetection_Trieste_TutorialKit/Processing`). Click **Run**.

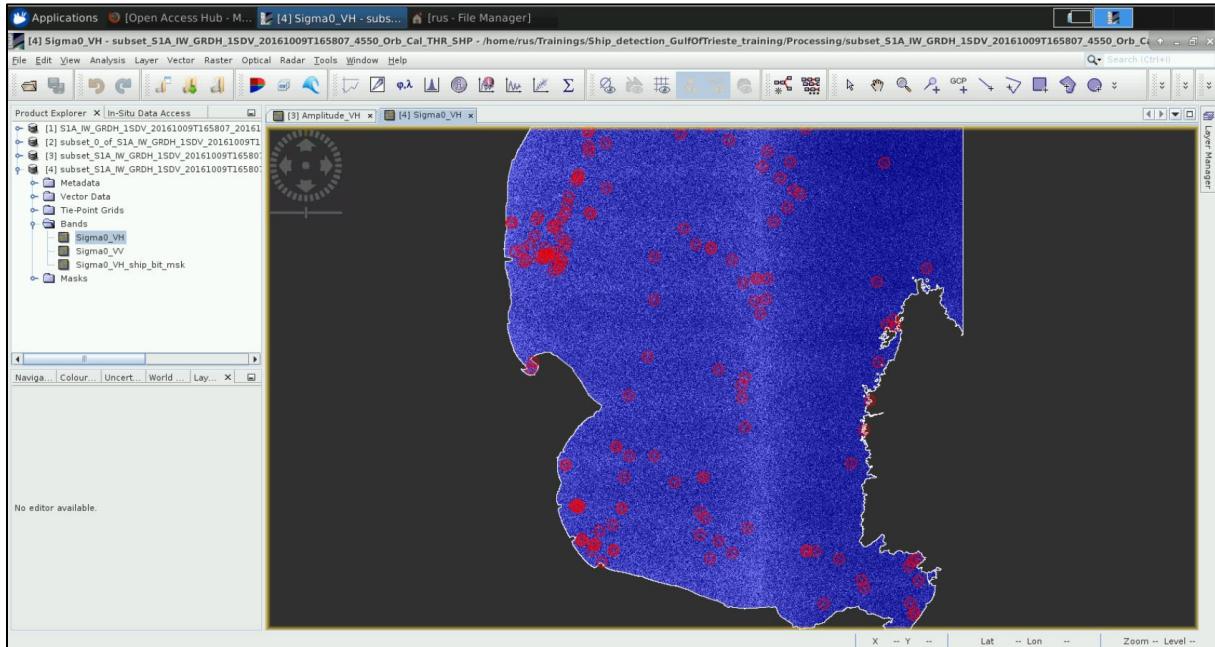


*Approximate processing time: 5.38 minutes.*

In **Product Explorer**, expand the newly created product:

`subset_0_of_S1A_IW_GRDH_1SDV_20161009T165807_Orb_Cal_THR_SHP`

and open band *Sigma\_VH*

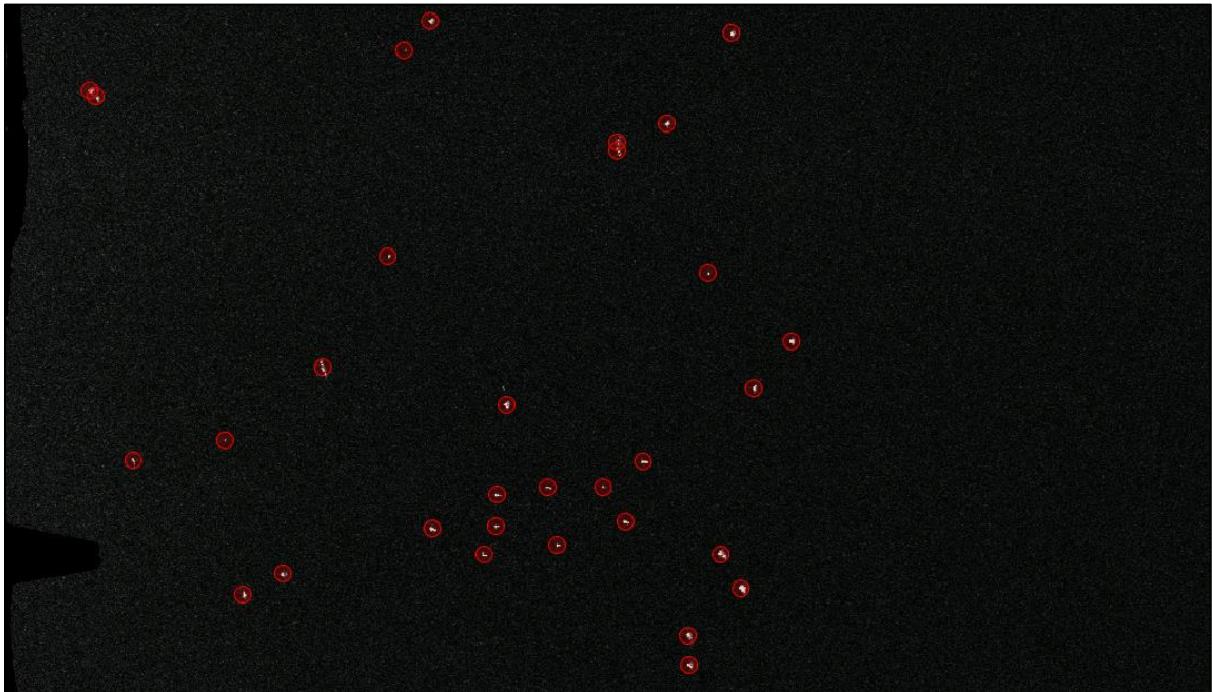


We can see the red circles representing targets but in the current visualization we cannot assess their accuracy. Let's enhance the view a little.

First, go to the **Layer Manager** pane on the right side of the SNAP window (or **View -> Tool Windows -> Layer Manager**), expand the *Vector data* folder and deselect *Gulf\_of\_Trieste\_seamask\_UTM33*.

Then go to **Colour Manipulation** tab also in the lower left corner and drag the white slider close to the end of the histogram (i.e. approximately to value 6.6E-2).

Now, we can actually see the bright targets (ships) within the red circles. **Zoom-in** to have better look.



Upon close inspection you can notice a few very small targets were missed. Target detection is all about optimizing the parameters to your data to achieve the lowest number of false detections and simultaneously the lowest number of missed targets. (see **TIP 3**)



**TIP 3:** Try running the detection again with different parameters. Generally the lower the PFA exponent, the more targets (false and real) you will capture. The same applies to the Target window size: the smaller target window, the more detection (detection of smaller targets but also for example two detections within a large target).

Combinations to try:

1. Adaptive thresholding: **TW: 15; GW: 500; BW: 800; PFA: 12.5;**  
Object-Discrimination: **MinTS: 15; MaxTS: 600**
2. Adaptive thresholding: **TW: 30; GW: 500; BW: 800; PFA: 9.0;**  
Object-Discrimination: **MinTS: 30; MaxTS: 600**

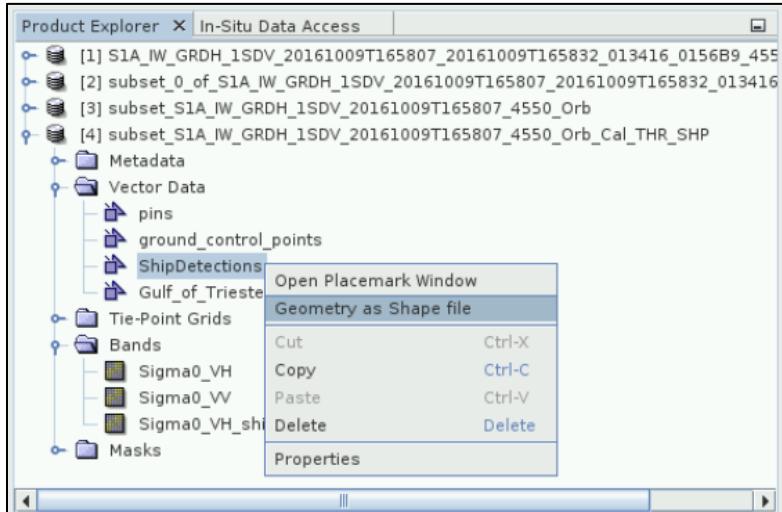
## 5.7 Export the results to Shapefile

Now we can export our results to an ESRI Shapefile (.shp) format that is more manageable and can be processed and visualized further in software such as QGIS.

Depending on the version of SNAP you have there might be a reoccurring bug that prevents simple export of the detections to ESRI shapefile format. Outlined below is a method to export for versions without the bug (OPTION 1) and a work-around method for versions with the bug (OPTION 2).

### 5.7.1 OPTION 1 – No error

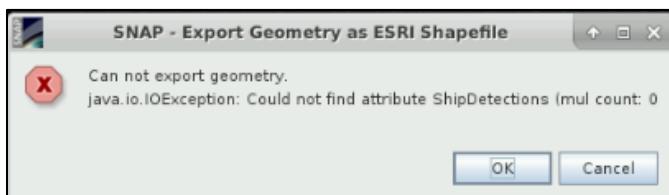
In **Product Explorer**, expand the ship detection product [4] and open the **Vector Data** folder. Right-click on the **ShipDetections** layer and select **Geometry as a Shapefile**.



Save the Shapefile to: [/shared/Training/OCEA01\\_ShipDetection\\_Trieste\\_TutorialKit/Processing](/shared/Training/OCEA01_ShipDetection_Trieste_TutorialKit/Processing).

### 5.7.2 OPTION 2 – SNAP versions with error

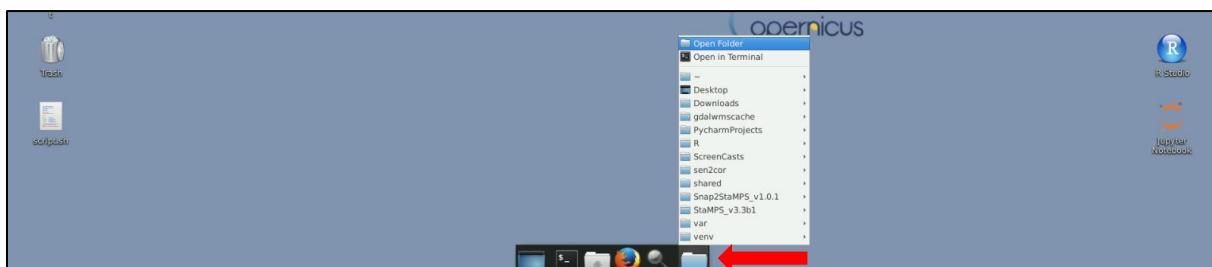
If the approach described in OPTION 1 does not work for you then the version of SNAP installed on your machine likely contains the mentioned error.



The detections are stored in the output product folder as a CSV:

[/shared/Training/OCEA01\\_ShipDetection\\_Trieste\\_TutorialKit/Processing/](/shared/Training/OCEA01_ShipDetection_Trieste_TutorialKit/Processing/)  
[subset\\_S1A\\_IW\\_GRDH\\_1SDV\\_20161009T165807\\_Orb\\_Cal\\_THR\\_SHP.data/vector\\_data/ShipDetections.csv](subset_S1A_IW_GRDH_1SDV_20161009T165807_Orb_Cal_THR_SHP.data/vector_data/ShipDetections.csv)

However, since our data is still not projected to a known projection such as WGS84, the table only contains pixel coordinates of the detections. We can get the detections and their lat/ion positions from the processing log. To do this, you need to open the **File Explorer**.



In the top of the file explorer window, go to **View -> Show hidden files**. Then navigate to `/home/rus/.snap6/var/log`. Here you can find a file named:

`subset_S1A_IW_GRDH_1SDV_20161009T165807_4550_Orb_Cal_THR_object_detection_report.xml`

Right click the file and go to **Open With -> Open With “Mousepad”**.

When the file opens in a text editor delete first three and last three lines (including the empty line) as shown below.

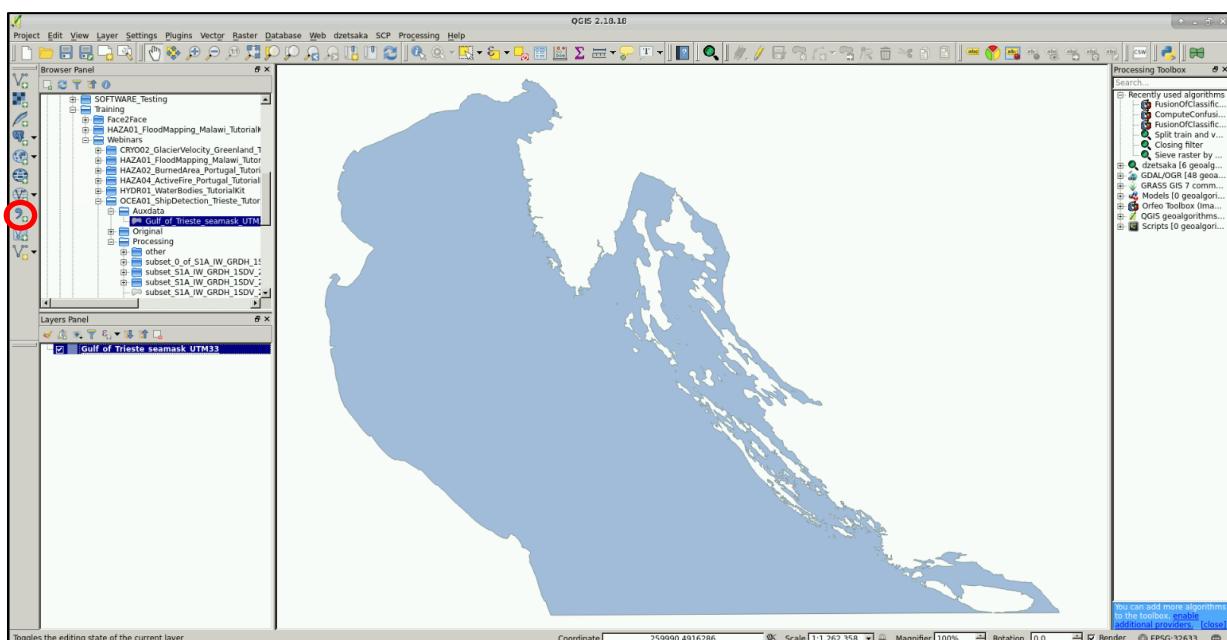
```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <Detection>
3   <targetsDetected bandName="Sigma0 VH ship bit msk">
4     <target Detected_x="2832" Detected_y="122" Detected_lat="44.16684875925067"
      Detected_lon="12.719833039500125" Detected_width="190.0" Detected_length="190.0" />
5     <target Detected_x="2794" Detected_y="181" Detected_lat="44.171520814618745"
      Detected_lon="12.713796490646743" Detected_width="20.0" Detected_length="30.0" />
...
129     <target Detected_x="13252" Detected_y="15539" Detected_lat="45.71888131167906"
      Detected_lon="13.659215701453894" Detected_width="270.0" Detected_length="110.0" />
130     <target Detected_x="13197" Detected_y="15622" Detected_lat="45.72553479265361"
      Detected_lon="13.650374777278873" Detected_width="250.0" Detected_length="140.0" />
131   </targetsDetected>
132 </Detection>
133
```

Then go to **File -> Save as**, and save the file to the *Processing* folder as *object\_detection\_report.txt*

Now, we can open QGIS. Go to **Applications -> Processing** and open **QGIS Desktop**. Navigate to `/shared/Training/OCEA01_ShipDetection_Trieste_TutorialKit/Auxdata` in the **Browser pane** on the left and double click the `Gulf_Of_Trieste_seamask_UTM33.shp` (see TIP 4).

**TIP 4:** To change the appearance of the layer right-click the layer in the Layers pane in lower left and go to Properties. Click on Simple fill and edit the appearance or select one of the predefined settings on the right. Click OK

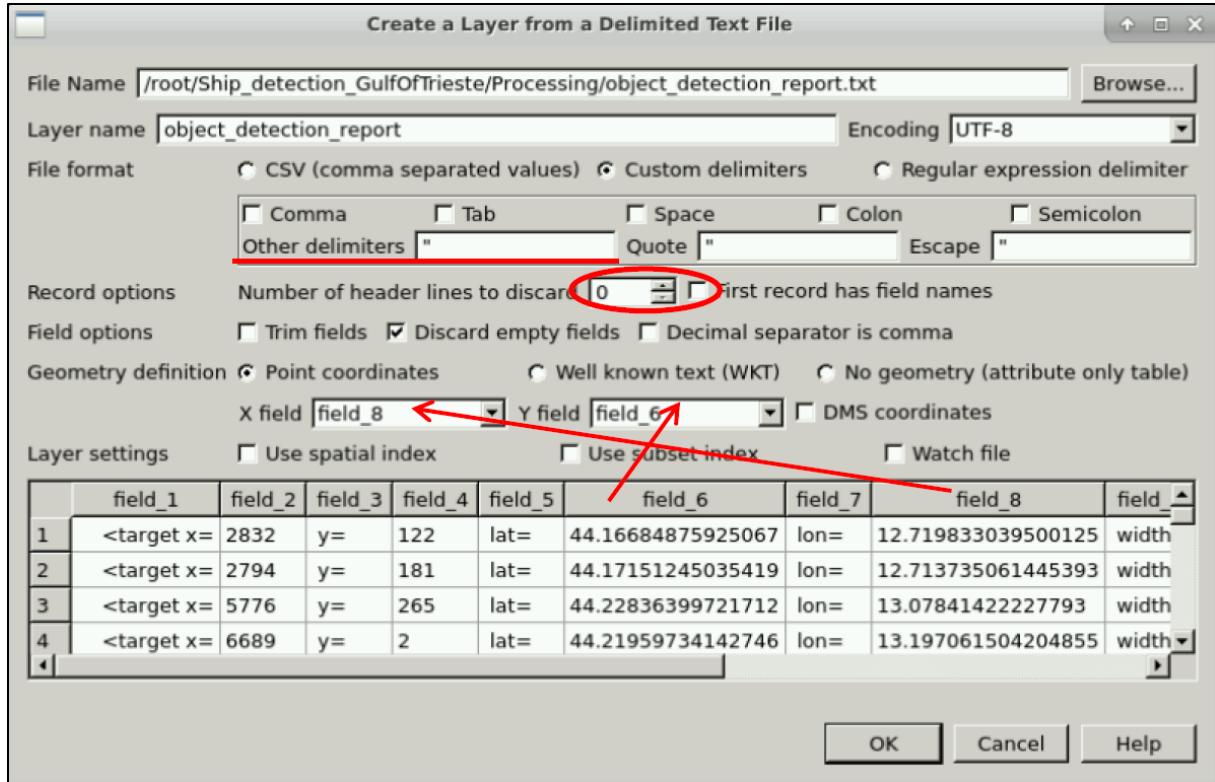
Now, click on the “Add Delimited Text Layer” in the vertical menu on the left of the window.



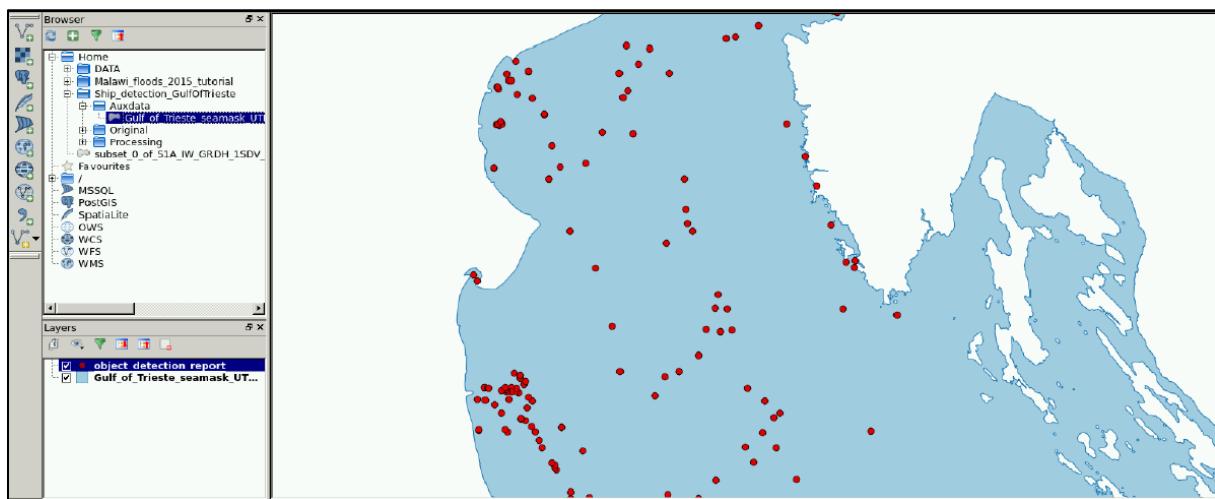
In the window that opens, click **Browse** and navigate to the saved *object\_detection\_report.txt*

A table will appear in the bottom of the window. Select **Custom delimiters**, unselect all other delimiters and in **Other Delimiter** type: “

Keep the remaining options and set the X and Y fields exactly as shown below (x field = Longitude, y field = Latitude). Then, click **OK**.



Now, we can check the coordinate reference system of the data. Right-click the new layer and go to **Properties** -> **General**. Check that the **Coordinate reference system** is set to **EPSG 4326** which corresponds to WGS 84 geographic coordinate system. Click **OK**.



We can now right click the *object\_detection\_report* layer and go to **Save as**. A variety of formats including shapefile and SHP are available. Let's choose SHP format and save the layer to the Processing folder as *ShipDetections\_Point.shp* (Check CRS is set to EPSG4326, WGS 84). Click **OK**.

## 5.8 Visualization in QGIS

Now, we can proceed with visualization of our results in QGIS. If not already opened, go to **Applications -> Processing** and open **QGIS Desktop**. Navigate to:

/shared/Training/OCEA01\_ShipDetection\_Trieste\_TutorialKit/Processing in the Browser pane on the left and double click the **ShipDetections\_Point.shp**. (see  TIP 5)

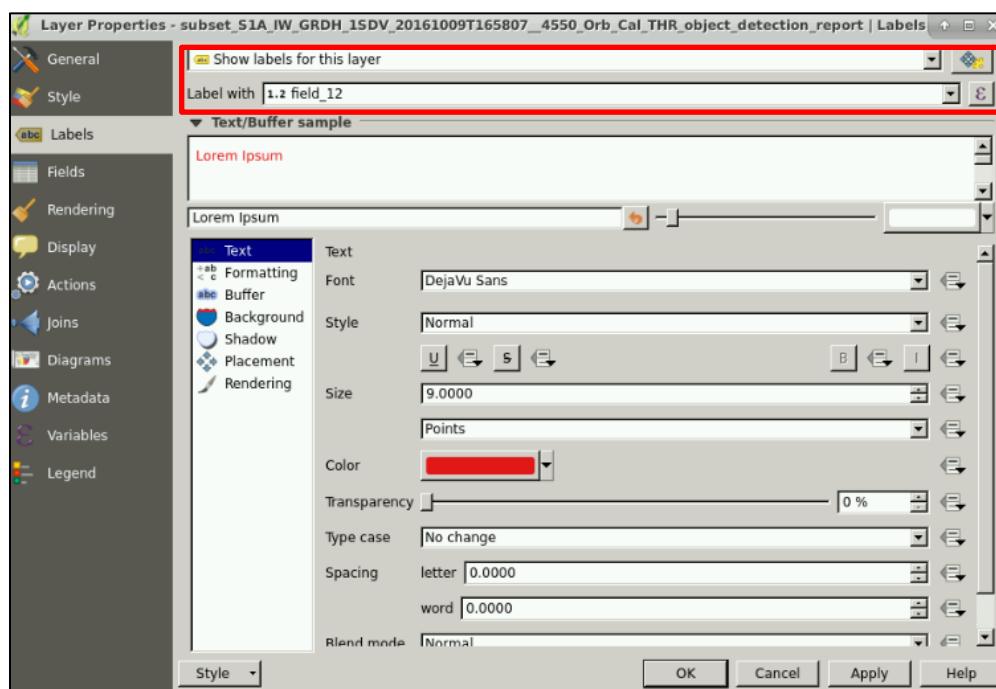
 **TIP 5:** To change the appearance of the layer, right-click the layer in the Layers pane in lower left and go to **Properties**. Click on Simple fill and edit the appearance or select one of the predefined settings on the right. Click **OK**.

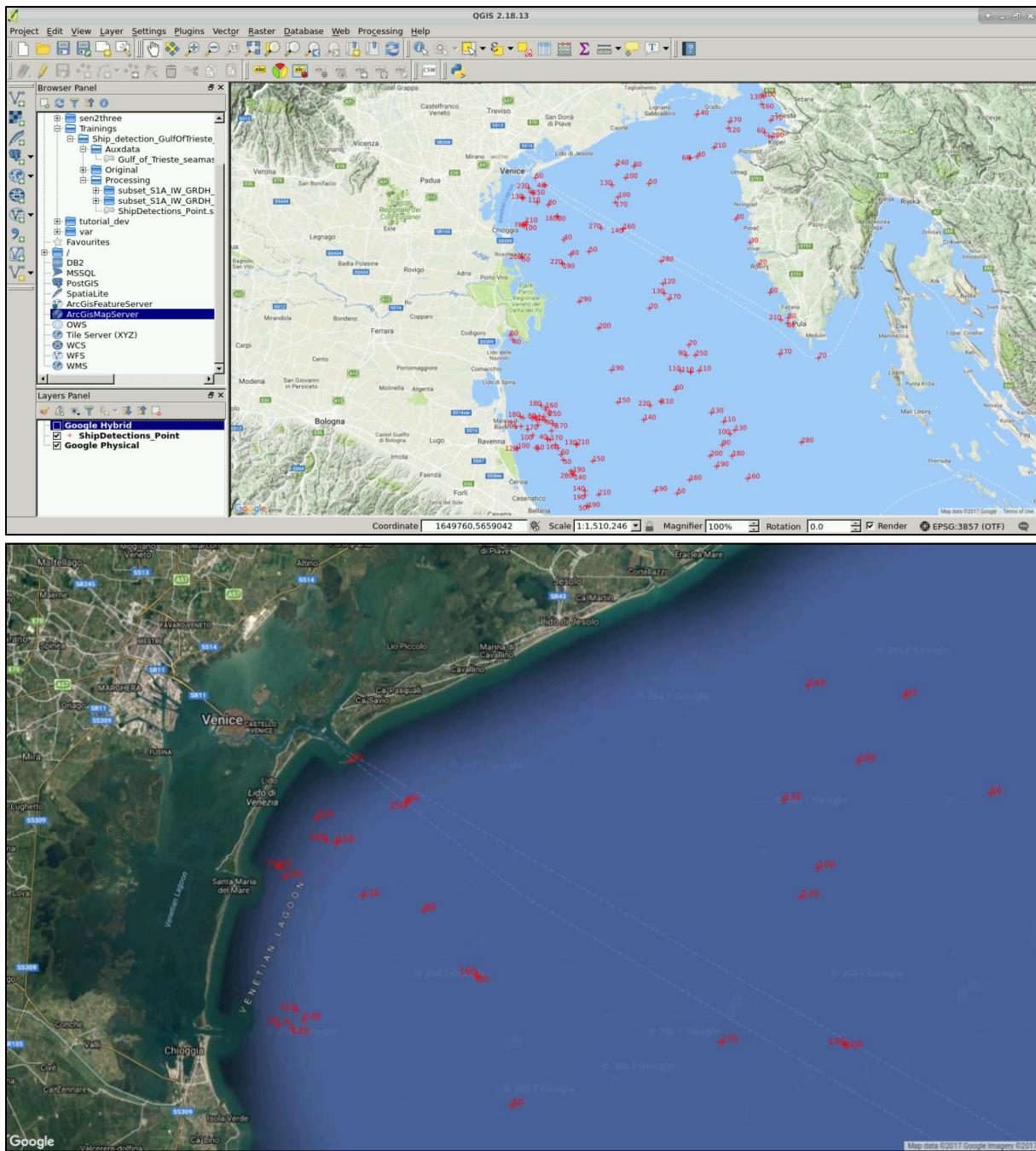
You can also set labels to show, such as the estimated length of the target in **Properties -> Labels**.

To visualize the location better, let's open a basemap from the **Open Layers** plugin (see  TIP 6). Go to **Web -> OpenLayers plugin -> Google Maps -> Google Physical** (or other).

 **TIP 6:** If you do not have the OpenLayers plugin installed you can do so by going to **Plugins -> Manage and Install Plugins**. Search for OpenLayers and then click **Install**.

We can then enhance the visualization by adding label containing the length of the detected object. The length value is stored in “*field\_12*” of the attribute table. Right-click the layer and go to **Properties -> Labels**. Select “Show labels for this layer” and **Label with:** *field\_12*.

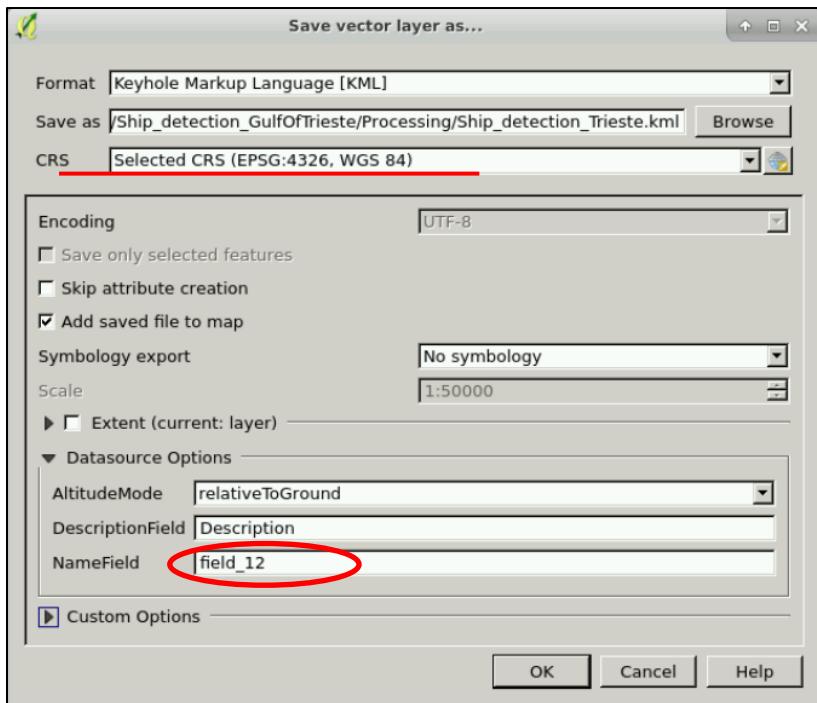




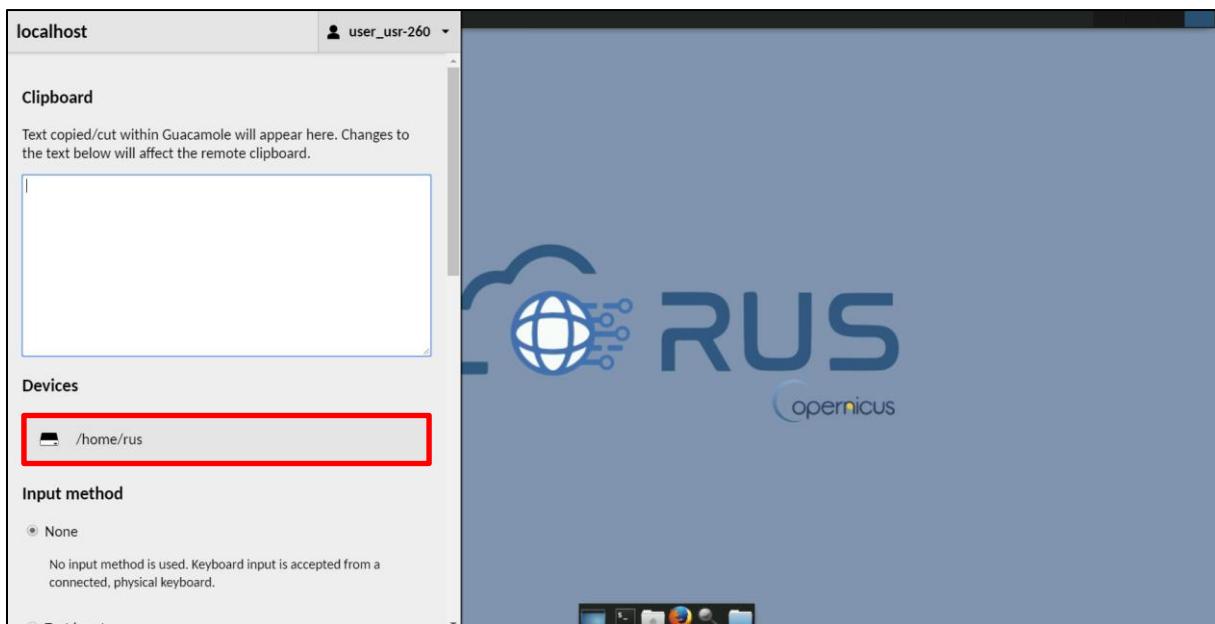
## 6 Other suggested steps

### 6.1 Downloading the outputs from VM and visualization in Google Earth

We can also visualize the detections in Google Earth by exporting them to KML format. We can do this by right-clicking on the the *ShipDetection\_Points.shp* and go to **Save as**. Choose KML format and save the layer to the Processing folder as *ShipDetection\_Points.kml* (Check **CRS** is set to EPSG4326, WGS 84). Expand **Datasource Options**. **NameField** write: “field\_12” (contains the length of the targets). Click **OK**.

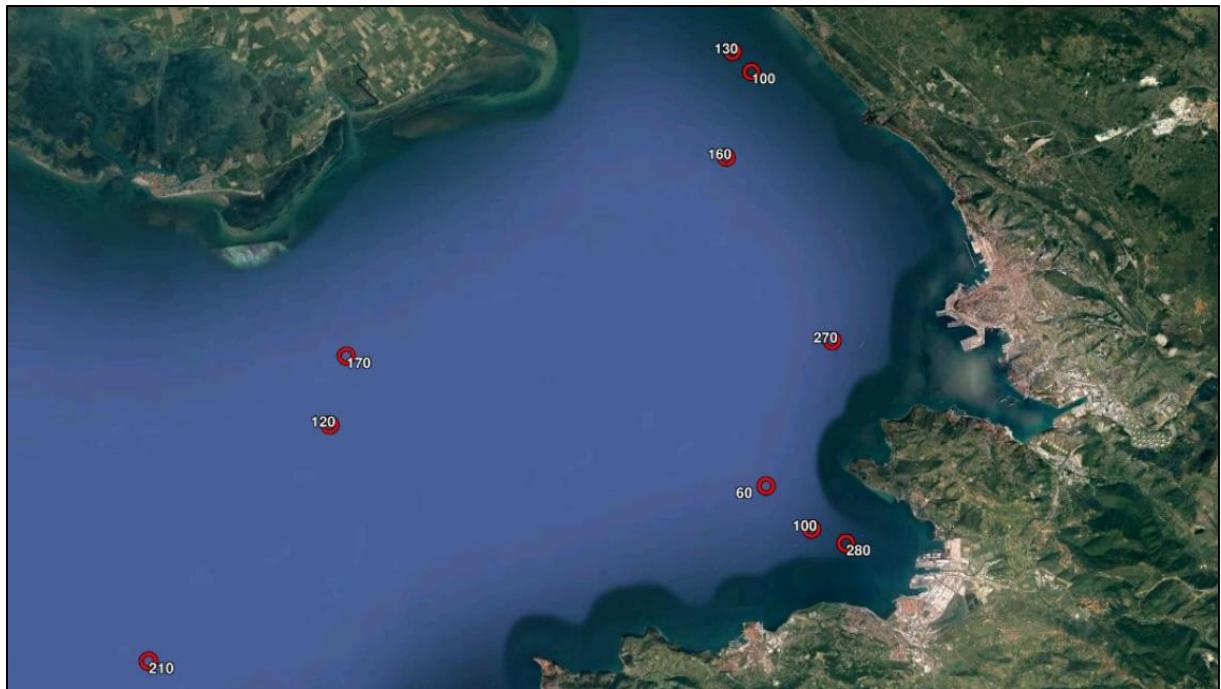


Close the QGIS without saving and press **Ctrl+Alt+Shift**. A pop-up window will appear on the left side of the screen.



Click on bar below **Devices**, the folder structure of your VM will appear. Navigate to your Processing folder and **double click the created KML file *Ship\_detection\_Trieste.kml*** to download it to your local computer.

Once the KML file has been downloaded you can visualize in your local Google Earth installation or upload it to Google Earth Web.



THANK YOU FOR FOLLOWING THE EXERCISE!

## 7 Further reading and resources

Stasolla, M., Fernandez Arguedas, V., Argentieri P., Alvarez, M., Santamaria, C., Greidanus, H. (2015). *Sentinel-1 Maritime Surveillance*. European Commission, Joint Research Centre, Institute for Institute for the Protection and Security of the Citizen, doi:10.2788/090400.

Barale, V. and Gade, M. (2008). *Remote Sensing of the European Seas*. Springer Science & Business Media. doi: 10.1007/978-1-4020-6772-3

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