

TRAINING KIT – HAZA04

ACTIVE FIRE DETECTION WITH SENTINEL-3 SLSTR (SNAP) JUNE 2017, PORTUGAL









Research and User Support for Sentinel Core Products

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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 derived from the Copernicus Sentinel satellites constellation.



Portugal wildfires June 2017 Credits: www.theguardian.com [June 18, 2017]

A series of four initial deadly wildfires erupted across central Portugal in the afternoon of 17 June 2017 within minutes of each other. An intense heat wave preceded the fires, with many areas of Portugal seeing temperatures in excess of 40 °C (104 °F).

During the night of 17–18 June, 156 fires erupted across the country, particularly in mountainous areas 200 km (120 mi) northnortheast of Lisbon.

Portugal's fires have burnt 520,000 hectares of forest this year, 52 times the size of Lisbon and

representing nearly 60 % of the total area burnt in the entire European Union in 2017. The amount of land burnt is the highest ever in Portugal's history.

2 Training

Approximate duration of this training session is two hours.

The Training Code for this tutorial is HAZA04. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the <u>RUS portal</u> and open a User Service request from Your RUS service \rightarrow Your dashboard.

2.1 Data used

Two cloud-free Sentinel-3A Level 1B RBT products acquired on June 18, 2017 (after the main event). [downloadable @ <u>https://scihub.copernicus.eu/]</u>
 S3A_SL_1_RBT____20170618T104548_20170618T104848_20170618T125104_0179_019_051_2340_SVL_O_NR_002.zip
 S3A_SL_1_RBT____20170618T220242_20170618T220542_20170619T003422_0179_019_058_0539_SVL_O_NR_002.zip

2.2 Software in RUS environment

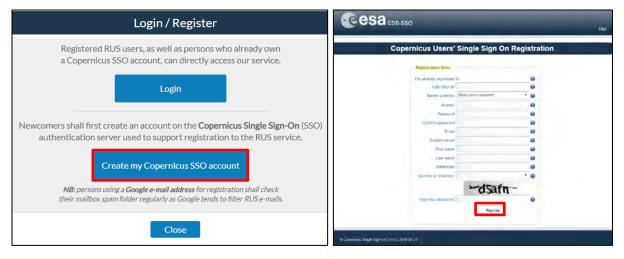
Internet browser, SNAP + Sentinel-3 Toolbox, QGIS, (Extra steps: Google Earth)

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 (<u>www.rus-copernicus.eu</u>) and click on *Login/Register* in the upper right corner.

CORRUS Research and User Support	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community *	
	Senth
	News from RUS
	One year on!
	Copernicus Info Session - Reykjavik - 19 September 2018
The second second	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
Welcome to Research and User Support	RUS Training Session – Valencia – 22 July 2018
	IGAR55 2018 - Valencia - 22-27 July 2018
Welcome to the Copernicus Research and User Support (RUS) Service portal!	The RUS agenda
The RUS Service is the "New Expert Service for Sentinel Users" funded by the European Commission,	Conferences & Workshops

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 email to activate your account.

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

Login / Register	Credentials			_
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:	CDS-SSO ID Password Max Idle Time Max Session Time	half a day Until browser close	•	0000
Login		Forgot your password?		ļ

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

The RUS Service * The RUS C	Do you want t	to subscribe for a new RUS account?		
	Your ESA-SSO subscription	data:		
+ Your RUS service	Login	Second State		٩
This section gathers pages related to m	FirstName			
· Your profile: displays your parent	Last Name	(matter)	us	
	Email	terminal contractions	Est.Forum - Str	
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	Please complete the follow	ing information:		
	Where did you hear about the	outreach event	NOON SHARES -	
	RUS service? Select one or more items	colleagues	former Deltania	
	Select one or more items	newsletter conference		
		social media other		
	Institution type	Select one item	v nda	
	Phone number Italy (IT):	+39	pristano-	
	Title	Select one item	~	

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**.

CORRUS Research and User Support	9 A K I	Hello, Miguel
The RUS Service * The RUS Offer * The RUS Library * The RUS Commu	nity Vour RUS service Vour RUS service Vour profile	You are here: Home > Your RUS serve
Your RUS service This section gathers pages related to your RUS services: Your profile: displays your personal information linked to your ESA SSO and RU	Your training	News from RUS One year on!
 Your dashboard: Illows you to access your private dashboard, Your training: allows you to register to a training session you have been invited 	to participate in.	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.

CORRUS Research and User Support	Helto, 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
Copyright © 2017 Research and User Support	onLact Us Terms and conditions Glossary Acronyms FAQ

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

ease help us learn more about your background by answering a few questio formation will be stored in your User Profile. ow many years of experience in Remote Sensing do you have? Choose one Item ave you already downloaded Copernicus data via the Copernicus Open access hubs? Yes No ave you already handled/processed Copernicus data? Yes No o you wish to practice a tutorial exercise shown in a RUS webinar? If yes, please select your of	nns. Th
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IAZA01 - Flood Mapping in Malawi	
IAZA02 - Burned Area Mapping in Portugal IYDR01 - Water Bodies Mapping over Northern Poland	- 11
AND01 - Crop Mapping in Seville	- 11
AND04 - Land Monitoring in Cyprus ICEA01 - Ship Detection in Gulf of Trieste	*
you wish to request another tutorial exercise that doesn't appear in the above list, please typ s name or code. Note that you can request multiple tutorial exercises.	pe here
	- Harde

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

	I HANDER COMPANY					
	a collection of information selected across the USR forms. ngo back and edit this information if necessary.					
foo can go back and eure bits information	n necessary.					
General information on your request:						
Years of experience in Remote Sensing	5-10 years					
Downloaded Copernicus data?	1					
Handled/processed Copernicus data?	1					
Webinar codes	HAZA02, LAND04					
About your RUS project:						
Thematicarea	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	1					
	S1 - Product 1					
S1 - Product type	GRD					
S1 - Sensor mode	4					
S1 - Polarisation	-					
S1 - Orbit direction	-					
Sentinel-2	X					
Sentinel-3	X					
Other	x					
I don't know	×					
Region of Interest: Min Latitude	39,3303					
Max Latitude	40.5877					
Min Longitude	-4.6736					
MaxLongitude	-2.7205					
Reference polygons	2.7.203					
Data acquisition date(s):						
None						
Additional data specifications						

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**.

							You are here: Home >	Your RUS service > Your dash
Your dashboard								
Request a new U	Jser Servi	ce					2	Chat with Support Desk
	1							
Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
	-			Follow my project	Get support	Close my service	Access my Virtual Machine(s)	Access my CPU monitoring dashboard
RUS_training1	231	2017-08-31	Open		Get a webinar kit	Rate my service	Freeze my Virtual Machine(s)	Report a technical incident

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.

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5 Data download – ESA SciHUB

In this example, we will download a Sentinel-3 scene from the Copernicus S-3 PreOpsHub using the online interface (Applications \rightarrow Network \rightarrow Web Browser or click the link below).

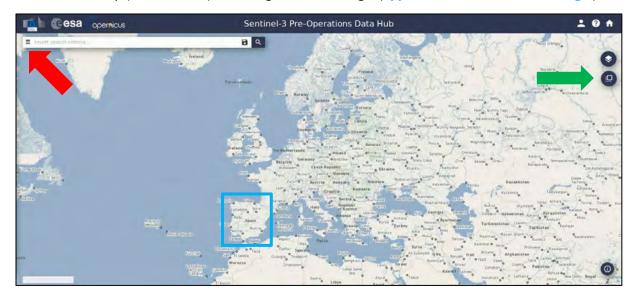
Go to https://scihub.copernicus.eu/



Go to "S-3 Pre-Ops", click "Login" in upper right corner and login using the credentials provided at the top of the login window.



Switch the rectangle-drawing mode to pan mode by clicking on the "**Pan**" icon in the lower left corner of the map (**Green arrow**) and navigate over Portugal (approximate area – blue rectangle).



Switch to drawing mode and draw a search rectangle approximately as indicated below. Open the search menu (red arrow) and specify the following parameters:

Sensing period: From 2017/06/18 to 2017/06/18 Check Mission: Sentinel-3 Product Type: SL_1_RBT___

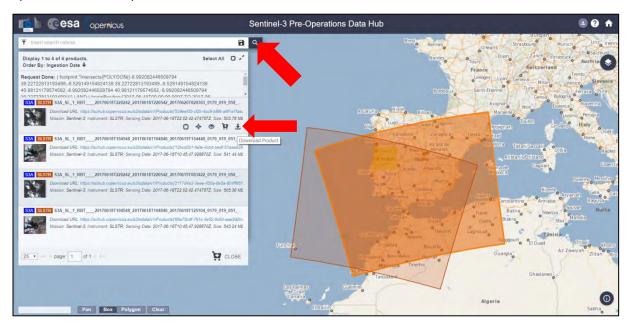
💼 🕜 🙋	a opernicus	Sentinel-3	Pre-Operations Data Hub	😑 😲 🏚
Insert search criteria.	-	8 9	yunath Broganca	Palencia
Advanced Search		Clear	Viana do Castelo Braga Zam	Valladõlid Outo
» Sort By	Ingestion Date		Nila Real	INAY
» Order By:	Descending		Ra A	Kill
» Sensing period	From: 2017/06/1 🞽 to:	2017/06/1	Avero View Guarda	Avila Madrid 20
» Ingestion period	From: <u> </u>	-•	Doimbro Portugai	Torres Mostoles
Product Type	Timeliness		Lamo Castelo	Spell Toledo
SL_1_RBT		•	Santarem Aurtalegre	ALC: SALA
Instrument	Product Level		Badajoz Menda	Giudad Real
Relative Orbit Start [1-	385]		Udono Setubal	181
-	Pan Box Polygon	Clear	Beja	- LO

In our case, the search returns 4 results. However, the second pair is the same data processed at different facility. Therefore, let's download the first pair (pay attention to date and time of acquisition, below in red):

S3A_SL_1_RBT____20170618T220242_20170618T220542_20170620T020303_0179_019_058_6599_LN2_0_NT_002 S3A_SL_1_RBT____20170618T104548_20170618T104848_20170619T154448_0179_019_051_2340_LN2_0_NT_002

Data will be downloaded to */home/rus/Downloads* as ZIP archives. Move the archives to */shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Original*

Right-click each archive and use "**Extract Here**" to unzip the folders. To open them in SNAP, go to open file and in the product, folder select **xfdumanifest.xml**.



6 Sentinel-3 SLSTR

SLSTR stands for **S**ea and **L**and **S**urface **T**emperature **R**adiometer. It is a dual scan temperature radiometer in the low Earth orbit (800 - 830 km altitude) on board of the Sentinel-3 satellite. It employs along track scanning dual view (nadir and backward oblique) technique for 9 channels in the visible (VIS), thermal (TIR) and short wave (SWIR) infra-red spectrum.

It also provides two dedicated channels for fire and high temperature event monitoring at 1 km resolution (by extending the dynamic range of the 3.74 μ m channel and including dedicated detectors at 10.85 μ m that are capable of detecting fires at ~650 K without saturation). (Sentinel-3 SLSTR User Guide, ESA).

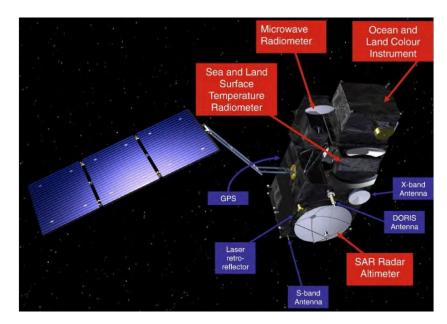
Band	λ centre (µm)	Width (µm)	Function	C	omments	Res. (m)		
S1	0.555	0.02	Cloud screening, vegetation monitoring, aerosol	Visible Near IR	Solar reflectance bands	500		
S2	0.659	0.02	NDVI, vegetation monitoring, aerosol					
S3	0.865	0.02	NDVI, cloud flagging, Pixel co- registration	Short- Wave IR				
S4	1.375	0.015	Cirrus detection over land					
S5	1.61	0.06	Cloud clearing, ice, snow, vegetation monitoring					
S6	2.25	0.05	Vegetation state and cloud clearing					
S7	3.74	0.38	SST, LST, Active fire	Thermal infra-red Ambient bands (200 K - 320 K)		1000		
S8	10.85	0.9	SST, LST, Active fire					
S9	12	1	SST, LST					
F1	3.74	0.38	Active fire	Thermal inf	ra-red fire emission bands			
F2	10.85	0.9	Active fire		Danus			

The nine bands in VNIR/SWIR/TIR (Credits: Sentinel-3 SLSTR User Guide, ESA)

It is distributed as Level-1b product (1 product - BRT) or Level-2 (4 products – WCT, WST, LST, FPR) products, based on the type and level of pre-processing applied to the raw data (not all products are available to public). In this training we will use the Level-1b RBT product, which consists of the full-resolution geolocated radiometric measurements for each view (n - nadir, o - oblique) and for each channel.

- on a 1 km grid for brightness temperatures (notation "_in" or "_io" bands S6 to S9 and F1 and F2 "fire bands")
- on a 0.5 km grid for radiances (S1 to S5). In this case, three stripes are distinguished: A ("_an", "_ao"), B ("_bn", "_bo"), and TDI ("_cn", "_co"), with TDI a derived product from A and B stripes.

IMPORTANT! In this tutorial, we will only use the nadir ("**_***in*") brightness temperature bands and nadir stripe A ("**_***an*") radiance bands.



Sentinel-3 sensors (Credits: Sentinel-3 SLSTR User Guide, ESA)

7 Step by step

7.1 SNAP – open project and explore data

Launch SNAP (icon on desktop). When the SNAP window opens click **Open Product** , navigate to: */shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Original* and open the S3 products by opening each folder and selecting the *xfdumanifest.xml* file.

At the pop-up window, choose "Sentinel-3 products" and click OK.

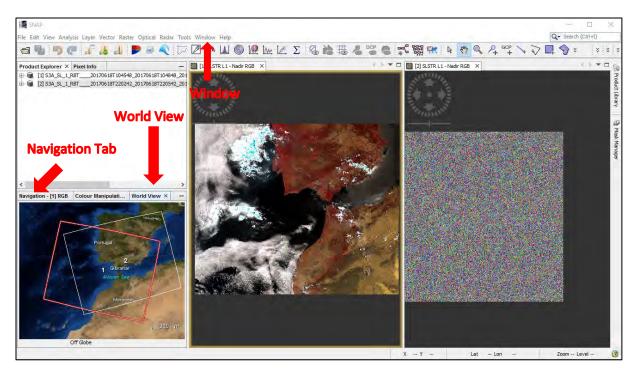
SNAP	SNAP - Multiple Readers Available 🛛 💿 🔍
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help	Multiple readers are available for the selected file. The readers might interpret the data differently. Please select one of the following:
	Sentinel-3 SLSTR L1B products in 1km resolution
Product Explorer × Pixel Info -	Sentinel-3 SLSTR LIB products in 1km resolution Sentinel-3 SLSTR LIB products in 500 m resolution Sentinel-3 products
	DK Cancel

Now, we will look at the products. Right-click the first loaded product acquired at **10:45** and click **Open RGB image window**, a new window will open. Set:

	L1 - Nadir	🗃 📙	
Red:	S3_radiance_an		~
Green:	S2_radiance_an		~
Blue:	S1_radiance_an		~
	S1_radiance_an	urt	~

Profile: SLSTR L1 Nadir

Now open the RGB view for the night product (acquired at **22:02**) as well. When you have both Views opened go to **Navigation** tab in the lower left and make sure the cursor \checkmark and the views \checkmark are linked. Then, go to **Window** \rightarrow **Tile Evenly**. Go back to **Navigation** tab and click **Qom All** to center the Views.



NOTE: If "World View" tab is not available, go to View → Tool Windows and open the "World Map".

Since we are creating the RGB View with radiance bands (reflected solar radiation), we cannot see anything in the night RGB composite, as expected. Go to the World View tab. We can see that the products do not cover exactly the same area - they correspond to different passes of the satellite.

Take a little time to explore the structure of the S3 products (expand them). During this exercise, we process two images - one acquired during the day (10:45) and one acquired during the night (22:02). You will notice that the RBT product contains many bands and even more masks, we do not need to worry about all of them though.

As mentioned before, we will only use the nadir bands with suffix "_in" (corresponding to 1 km brightness temperature bands S6 – S9 and fire bands F1 and F2) or "_an" (corresponding to radiance bands S1 – S5 in stripe A) in their name. Read about Sentinel-3 SLSTR RBT product and its organization and contents in section 6 Sentinel-3 SLSTR.

The processing of day and night acquisitions differ slightly, and we will go through the steps separately.

7.2 Pre-processing DAY

Cloud masking is essential to the detection of active fire pixels because optically thick clouds make it impossible to identify active fires through passive remote sensing. Moreover, solar reflected MIR radiation from certain clouds can appear similar to fire signals and some cloud-contaminated pixels will likely be falsely classified as fires if they are not masked out prior to fire detection. (Wooster et al., 2012).

The Level-1B product contains cloud mask, however some cloud mask algorithms also identify optically thick smoke as cloud, even though fire detections can typically be made through smoke. Smoke is generally relatively transparent at MIR wavelengths unlike meteorological cloud. This makes the cloud masks available in the product unsuitable for active fire detection and we need to derive our own mask.

We will use simple cloud test developed for daytime fire detection by Giglio et al. (2003).

 $\{(\rho_{0.65} + \rho_{0.86} > 0.9) \ OR \ (T_{12} < 265 \ K)\} \ OR \ \{(\rho_{0.65} + \rho_{0.86} > 0.7) \ AND \ (T_{12} < 285 \ K)\}$

Where, ρ_{λ} and T_{λ} correspond to reflectance and thermal bands at certain wavelength (λ [µm]).

7.2.1 Radiance to reflectance

As the Level-1B product contains TOA radiance, our first step will be to convert the solar radiance bands to reflectance (See NOTE 1).

NOTE 1: The conversion from TOA radiance (L_{TOA}) to TOA reflectance (R_{TOA}) is defined by the following equation:

$$R_{TOA}(\lambda) = \frac{\pi L_{TOA}(\lambda)}{E_0(\lambda)\cos(\theta)}$$

Where, E_0 and θ are the solar spectral irradiance and the sun zenith angle at the time of acquisition, respectively. The solar spectral irradiance values are taken from the L1 product metadata of the SLSTR product.

Radiance is the variable directly measured by remote sensing instruments. It is the amount of light seen by instrument from a surface of an object. In the SLSTR products is given as radiance of a surface per unit wavelength $[mW^*m^{-2*}sr^{-1*}nm^{-1} =$ watt per square meter per nanometre].

Reflectance is the ratio (percentage) of the amount of light leaving a target to the amount of light arriving to the target. It has no units. It is the property of the observed object/material.

Go to **Optical** → **Preprocessing** → **Radiance-to-Reflectance Processor**.

In the **I/O Parameters** tab, make sure that the **DAYTIME** product is selected as input. Set the **Name** of the target product to **S3A_SL_1_RBT_20170618T104548_radrefi** and the target folder under **Directory** to: */shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing*

In the Processing Parameters tab set:

Sensor: SLSTR_500m

Conversion mode: RAD_TO_REFL

Check all fields to "Copy tie point grids, flag bands and masks and non-spectral bands".

Radiance-to-Reflectance Processor X	Radiance-to-Reflectance Processor X
File Help	File Help
I/O Parameters Processing Parameters	I/O Parameters Processing Parameters
Source Product Name: [1] S3A_SL_1_RBT20170618T104548_20170618T10	Sensor: SLSTR_500m Conversion mode: RAD_TO_REFL Copy tie point grids
Target Product Name: SA_SL_1_RBT_20170618T104548_radrefi Save as: BEAM-DIMAP Directory: C:\Users\tsmejkalova\DATA\Tutorial_tests\Other	Copy flag bands and masks
Close	Run Close

Click **Run**. A new product [3] has been created. Click **OK** to the pop-up window and close the **Radiance-to-Reflectance Processor** window. If we expand the Bands folder in the product, we can see that the **brightness temperature** folders (*BT) have not changed but the **radiance** folders were replaced by **reflectance** folders. **Close all view windows**.

7.2.2 Resample

As mentioned previously, the brightness temperature (BT) bands of S3 RBT product have resolution of 1000 m while the radiance (now reflectance) bands have resolution of 500 m. For further processing, it is necessary to have all bands in the same resolution. As for the active fire detection we will use the BT bands and we will resample all the reflectance bands to 1000 m.

Go to Raster \rightarrow Geometric Operations \rightarrow Resampling.

In the **I/O Parameters** tab, make sure that the daytime reflectance product [3] is selected as input. Select **Save as**: \checkmark .

Set the **Name** of the target product to: *S3A_SL_1_RBT_20170618T104548_radrefl_resampled* and the target folder under **Directory** to: */shared/Training/HAZA04_ActiveFire_Portugal/Processing*

In th	e Processing	Parameters tab	set: Bv ref	erence band	from source	product: F1	ΒT	in
						p		

Resampling ×	Resampling	Х
File Help	File Help	
I/O Parameters Resampling Parameters	I/O Parameters Resampling Parameters	
Source Product	Define size of resampled product	^
Name:	By reference band from source product: F1_BT_in	
[3] S3A_SL_1_RBT_20170618T104548_radreff ~	Resulting target width: 1500	' I
Target Product	Resulting target height: 1200	
Name:	O By target width and height: Target width:	
S3A_SL_1_RBT_20170618T104548_radrefl_resampled	Target height:	
Save as: BEAM-DIMAP	Width / height ratio: 1.25000	
Directory:	O By pixel resolution (in m):	
C:\Users\tsmejkalova\DATA\Tutorial_tests\Other	Resulting target width:	
Open in SNAP	Resulting target height:	
	Upsampling method: Nearest	
	Downsampling method: First	
	Flag downsampling method: First	
	Resample on pyramid levels (for faster imaging)	~
	< >>	
Run Close	Run Clos	e

Click **Run**. A new product [4] has been created. Click **OK** to the pop-up window and close the **Resampling** window.

7.2.3 Reproject

The Sentinel-3 Level-1B products are geocoded but not projected, therefore in this step we will reproject the data.

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

In the **I/O Parameters** tab, make sure that the daytime resampled product [4] is selected as input. Set the name of the target product to:

S3A_SL_1_RBT_20170618T104548_radrefl_resampled_reprojected and the target folder under *Directory* to: */shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing* In the Reprojection Parameters tab set:

Under Coordinate Reference System (CRS) choose: Custom CRS and at Projection: UTM Zone Click on Projection Parameters and set as Zone: 29 and as Hemisphere: North

Reprojection X	Reprojection	UTM Zone - P X ×
File Help	File Help	Zone: 29
I/O Parameters Reprojection Parameters	I/O Parameters Reprojection Parameters	Hemisphere: North 🗸
Source Product	Coordinate Reference System (CRS)	
Name: [4] S3A_SL_1_RBT_20170618T104548_radrefl_resampled	Custom CRS	OK Cancel
	Geodetic datum: World Geodetic System 1984	~
Target Product	Projection: UTM Zone	~
Name:		Projection Parameters
S3A_SL_1_RBT_20170618T104548_radrefi_resampled_reprojected	Predefined CRS	Select
Save as: BEAM-DIMAP V Directory:	O Use CRS of	×
C:\Users\tsmejkalova\DATA\Tutorial_tests\Other\Active_fires\Processing		
Open in SNAP	Output Settings	
	Preserve resolution Reproject tie	e-point grids
	Output Parameters No-data value:	NaN
	Add delta lat/lon bands Resampling meth	od: Nearest 🗸 🗸
	Output Information	
	Scene width: 1501 pixel Center lon	ngitude: 8°17'40" W
	Scene height: 4298 pixel Center lat	
	CRS: UTM Zone 1 / World Geodetic System 1	984 S W WKT
Run Close		Run Close

Click **OK** and then click **Run**. A new product [5] has been created. Click **OK** at the pop-up dialog and close the **Reprojection** window.

7.2.4 Subset

In the last pre-processing step, we will create a subset of our area of interest. Click on the new product [5] in the **Product Explorer** window to highlight it.

Go to Raster → Subset.

In the **Spatial Subset** tab, at the **Geo Coordinates** tab, set the following coordinates:

Figure 2 Specify Product Subset			×
Spatial Subset Band Subset	Meta	data Subset	
	^	Pixel Coordinates Geo Coo	ordinates
		North latitude bound:	41.00 🖨
		West longitude bound:	-10.00 🜩
		South latitude bound:	38.00 🖨
		East longitude bound:	7.00 ≑
		Scene step X:	1 -
		Scene step Y:	1
		Subset scene width:	227.0
		Subset scene height:	289.0
		Source scene width:	1501
		Source scene height:	1293
			Fix full width
	~	Use Preview	Fix full height
		Estin	nated, raw storage size: 14.6M
		0	K Cancel Help

North latitude bound:	41.00
West longitude bound:	-10.00
South latitude bound:	38.00
East longitude bound:	-7.0

The subset area is indicated by the blue rectangle on the left of the dialog window. Click **OK.**

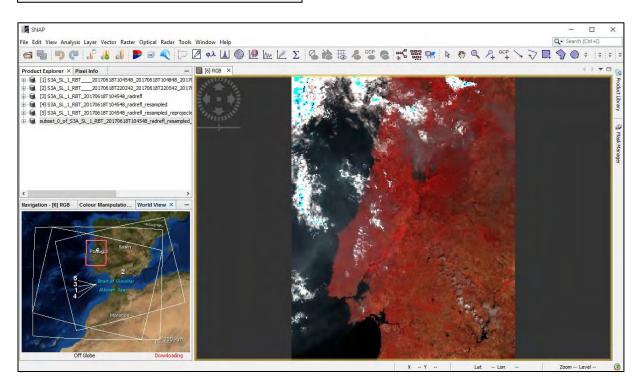
The subset product [6] will appear in the **Product Explorer** window but is not physically saved. We will save it after the creation of the cloud mask.

Right-click the product again and select **Open RGB Image Window** and set:

Selec	t RGB-Image Channels X	Re
Profile:		Gr
Red:	✓ 🔄 💾 11 \$6.53 reflectance an	Bl
Green:	\$6.53_reflectance_an > \$6.52_reflectance_an >	
Blue:	¢6.S1_reflectance_an ✓	
C Stor	Expressions are valid re RGB channels as virtual bands in current product	
	e koo chamies as virtuai barius in current product	
	OK Cancel Help	Cli

- Red:\$6.S3_reflectance_anGreen:\$6.S2_reflectance_an
- Blue: \$6.S1_reflectance_an

Click **OK**.



7.2.5 Create a cloud mask band

As discussed before, we will create our own cloud mask. Right-click on the subset product [6] and click **Band Maths**. A new window will open.

TIP: All expressions you will be using during this tutorial are available to copy-paste them from the *Expressions_AF.txt* file in */shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Auxdata/* folder.

Set as Name: "cloud_mask"

Deselect "Virtual (safe expression only, don't store data)"

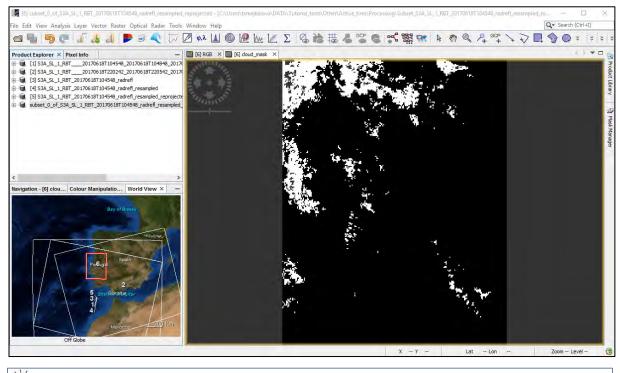
Then click on "Edit Expression..." and enter the following statement:

(S2_reflectance_an + S3_reflectance_an) > 0.9 or S9_BT_in < 265 or ((S2_reflectance_an + S3_reflectance_an) > 0.7 and S9_BT_in < 285)</pre>

Click **OK** in both windows.

🗱 Band Maths 🛛 🕹	Band Maths Expression Editor			×
Target product: [6] subset_0_of_S3A_SL_1_RBT_20170618T1 Name: doud_mask Description: Unit: Spectral wavelength: 0.0	Data sources: S1_reflectance_an S2_reflectance_an S3_reflectance_an S4_reflectance_an S5_reflectance_an S5_reflectance_an		0 + 0 0 - 0 0 * 0 0 / 0	Expression: (S2_reflectance_an + S3_reflectance_an) > 0.9 or S9_BT_in < 265 or ((S2_reflectance_an + S3_reflectance_an) > 0.7 and S9_BT_in < 285)
tual (save expression only, don't store data) Replace NaN and infinity results by NaN Generate associated uncertainty band Band maths expression: (S2_reflectance_an + S3_reflectance_an) > 0.9 or S9 Load Edit Expressio	So_reflectance_ao S2_reflectance_ao S3_reflectance_ao S4_reflectance_ao S4_reflectance_ao Show bands Show masks Show the point grids	>	(@) Constants ~ Operators ~ Functions ~	
OK Cancel Help	Show single flags			OK Cancel Help

The new band will automatically open in a new "View" window.



TIP: You can also build the expression yourself using the **Expression Editor**.

Right-click the subset product [6] and go to **Save Product**. In the next dialog click **Yes** and save the product as **Subset_S3A_SL_1_RBT_20170618T104548_radrefl_resampled_reprojected** to **/shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing**

7.3 Pre-processing NIGHT

The preprocessing steps are the same for the night product with the exeption of the radiance to reflectance conversion. To derive the night cloud mask we do not need the reflectances, only the brightness temperature bands therefore only the **Resampling**, **Peprojection** and **Subset** steps will be applied.

Similarly as for the day-time product, Night-time pixels are flagged as cloud if the single condition is satisfied. (Giglio et al. (2003)).

$T_{12} < 265 K$

Where, T_{12} correspond to thermal band S9, at central wavelength of 12 $\mu m.$

7.3.1 Resample

Follow the steps described in section 7.2.2 Resample.

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

In the **I/O Parameters tab**, make sure that the **NIGHT**-time product [2] is selected as input. Select **Save as**: \checkmark .

Set the **Name** of the target product to **S3A_SL_1_RBT_20170618T220242_resampled** and the target folder under **Directory** to: **/shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing**.

In the Processing Parameters tab set: By reference band from source product: F1_BT_in

Click **Run**. A new product [7] has been created. Click **OK** to the pop-up window and close the **Resampling** window.

7.3.2 Reproject

Follow the steps described in section 7.2.3 Reproject.

Go to **Raster** \rightarrow **Geometric Operations** \rightarrow **Reprojection**.

In the **I/O Parameters tab**, make sure that the night-time resampled product [7] is selected as input. Set the name of the target product to: **S3A_SL_1_RBT_20170618T220242_resampled_reprojected** and the target folder under **Directory** to:

/shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing

In the Reprojection Parameters tab set:

Under **Coordinate Reference System (CRS)** choose: **Custom CRS** and at **Projection**: UTM Zone Click on **Projection Parameters** and set as **Zone**: 29 and as **Hemisphere**: North

Click **OK** and then click **Run**. A new product [8] has been created. Click **OK** at the pop-up dialog and close the **Reprojection** window.

7.3.3 Subset

Follow the steps described in section 7.2.4. Subset. Click on the new product [8] in the **Product Explorer** window to highlight it.

Go to Raster → Subset.

In the **Spatial Subset** tab, at the **Geo Coordinates** tab, set the following coordinates:

North latitude bound:	41.00	West longitude bound:	-10.00
South latitude bound:	38.00	East longitude bound:	-7.0

Click **OK**. The subset product [9] will appear in the **Product Explorer** window but is not physically saved. We will save it after the creation of the cloud mask.

7.3.4 Create a cloud mask band.

As discussed before, we will create our own cloud mask. Right-click on the subset product [9] and click **Band Maths**. A new window will open.

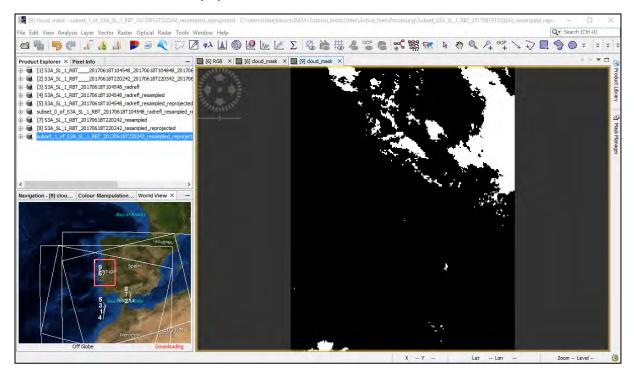
Set as Name: "cloud_mask"

Deselect "Virtual (safe expression only, don't store data)"

Then click on "**Edit Expression...**" and enter the following statemen S9 BT in < 265

Band Maths X	Band Maths Expression Editor		×
Target product:	Data sources:		Expression:
[9] subset_1_of_S3A_SL_1_RBT_20170618T2202 ~	x_an ^	@ + @	S9_BT_in < 265
Name: cloud_mask_	y_an	0 - 0	
Description:	x_ao	@ * @	
Unit:	<u>у_ао</u>	@ * e	
Spectral wavelength: 0.0	x_bn	@ / @	
	y_bn	(@)	
Virtual (save expression only, don't store data)		Constants V	
Replace NaN and infinity results by NaN	y_bo	Operators V	
Generate associated uncertainty band	x_cn	Functions V	
Band maths expression:	y_cn v ·	runcorons	
S9_BT_in < 265	Show bands		
	Show masks		
Load Save Edit Expression	Show tie-point grids		
	Show single flags		📑 🛅 🔉 ն
OK Cancel Help		OK	Cancel Help

The new band will automatically open in a new "View" window.



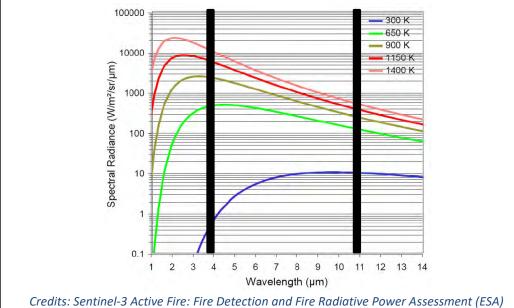
Right-click the subset product [9] and go to **Save Product**. In the next dialog click **Yes** and save the product as **Subset_S3A_SL_1_RBT_20170618T220242_resampled_reprojected** to **/shared/Training/HAZA04_ActiveFire_Portugal_TutorialKit/Processing**

Now both of our products are ready for Active Fire Pixel Detection. Let's close SNAP window completely and open a new one.

7.4 Active fire detection

In this step, we will apply a simple algorithm to identify pixels containing one or more active fires at the time of the satellite overpass. This approach exploits the different responses of middle-infrared (MIR) and thermal-infrared (TIR) bands to hot subpixel targets. In particular, the algorithm looks for a significant increase in radiance (brightness temperature) at $3.74\mu m$ in comparison to observed radiance (BT) at $10.85\mu m$ as well as in absolute value (See \frown NOTE 2).

NOTE 2: This characteristic active fire signature is the result of the large difference in blackbody radiation at 4µm and 11µm, emitted at vegetation combustion temperatures, as described by the Planck function. The image below shows the spectral radiance emitted from blackbodies at Earth ambient temperature (300 K) and a range of possible vegetation fire temperatures (650 - 1400 K). The approximate central wavelengths of the Sentinel-3 SLSTR MIR (3.74µm) and TIR (10.85µm) channel are also indicated.



🛃 Add Land Cover Band						
Land Cover Model:						
AAFC Canada 2015 Crop AAFC Canada 2016 Crop AAFC Canada 2016 Crop SMAPVEX AAFC Canada Clay Pct AAFC Canada Sand Pct	^					
AAFC Canada Sand Pct CCILandCover-2015 GLC2000 GlobCover MODIS 2007 Tree Cover Percentage MODIS 2010 Tree Cover Percentage						
Resampling method:						
NEAREST_NEIGHBOUR						
Integer data types will use nearest neighbour Land cover band name: CCILandCover-2015						
OK Can	cel					

As described in section **7.1 SNAP – Open Project and Explore Data** there are two bands (F1 and F2, "fire channels") dedicated to fire detection (greatly increased saturation temperature threshold).

In the new SNAP window, click **Open Product** , navigate to: */shared/Training/HAZA04_ActiveFire*

_Portugal_TutorialKit/Processing and open both subset products we have created during the pre-processing phase.

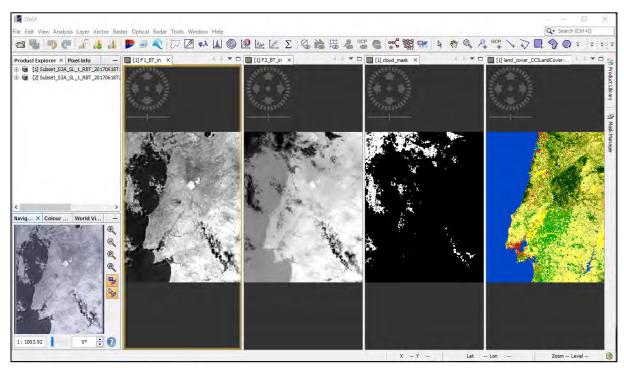
Right-click the daytime product and select **Add Land Cover Band**, in the dialog that appears, scroll down and select "**CCILandCover-2015"**, and then click **OK**.

This will add a new band containing the land cover layer. Repeat the same for the night-time product.

7.4.1 Daytime fire detection

Now, let's visualize all the bands we will use to define the fire detection algorithm for the daytime product. Expand the daytime product folder go to **Bands** \rightarrow "**F*****BT_in**" folder, double-click both bands ["**F1_BT_in (3742 nm)**", "**F2_BT_in (10854 nm)**"] to open them both in the **View** Window. Next, scroll down to the bottom of the **Bands** folder and double-click "cloud_mask" and "land_cover_CCILandCover-2015" band.

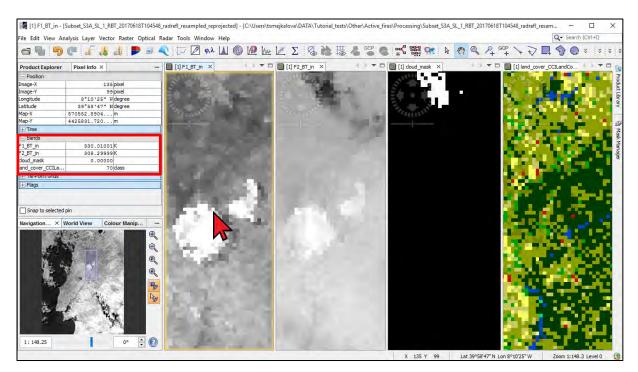
Go to Window \rightarrow Tile Horizontally and in Navigation tab select Zoom all. In the Product Explorer window, collapse all the expanded folders.



Click on the "land_cover_CCILandCover-2015" view, go to Colour Manipulation tab and inspect the classes in the land cover layer. Which classes will be correlated with forest fires?

Label	Colour	Value	Freque	100 Mosaic T and shrub (>50	100	0.000%
				110 Mosaic herbaceous cover (110	0.000%
0 No data		U	0.000%	120 Shrubland	120	2.692%
10 Cropland, rainfed		10	0.000%	121 Shrubland evergreen	121	0.000%
11 Herbaceous cover		11	0.000%	122 Shrubland deciduous	122	0.000%
12 Tree or shrub cover		12	0.000%	130 Grassland	130	0.000%
20 Cropland, irrigated or post?		20	0.000%	140 Lichens and mosses	140	0.000%
30 Mosaic cropland (>50%) / n		30	0.000%	150 Sparse vegetation (tree, s	150	0.000%
40 Mosaic natural vegetation (40	0.000%	151 Sparse tree (<15%)	151	0.000%
50 Tree cover, broadleaved, e		50	0.000%	152 Sparse shrub (<15%)	152	0.000%
60 Tree cover, broadleaved, d		60	0.000%	153 Sparse herbaceous cover	153	0.000%
61 Tree cover, broadleaved, d		61	0.000%	160 Tree cover, flooded, fresh	160	0.000%
62 Tree cover, broadleaved, d		62	5.705%	170 Tree cover, flooded, salin	170	5.668%
70 Tree cover, needleleaved,		70	10.054%	180 Shrub or herbaceous cove	180	0.000%
71 Tree cover, needleleaved,		71	2.492%	190 Urban areas	190	0.000%
72 Tree cover, needleleaved,		72	0.000%	200 Bare areas	200	0.000%
80 Tree cover, needleleaved,		80	0.000%	201 Consolidated bare areas	201	0.000%
81 Tree cover, needleleaved,		81	0.000%	202 Unconsolidated bare areas	202	0.000%
82 Tree cover, needleleaved,		82	0.000%	210 Water bodies	210	0.000%
90 Tree cover, mixed leaf type		90	0.000%	220 Permanent snow and ice	220	0.000%

Now zoom to the bright spot in the center of "F1_BT_in band (3742nm)". All other views will zoom to the same area. Inspect other opened bands by going to the Pixel Info window; there you can see the values of the pixel over which you move your cursor in all opened bands.



Now go back to **Product Explorer** window and let's design our test to detect active fire pixels. Pixel is classified as fire-pixel if the following conditions are true:

Initial test	F1_BT_in > 325 K
Eliminate warm background	(F1_BT_in - F2_BT_in) > 18 K
Eliminate clouds	cloud_mask == 0
Eliminata non forast nivels	'land_cover_CCILandCover-2015' >= 50 and
Eliminate non-forest pixels	'land_cover_CCILandCover-2015' <= 130

Right-click the daytime product and go to Band Maths.... A new window will open.

Set as Name: fire_detection_LC

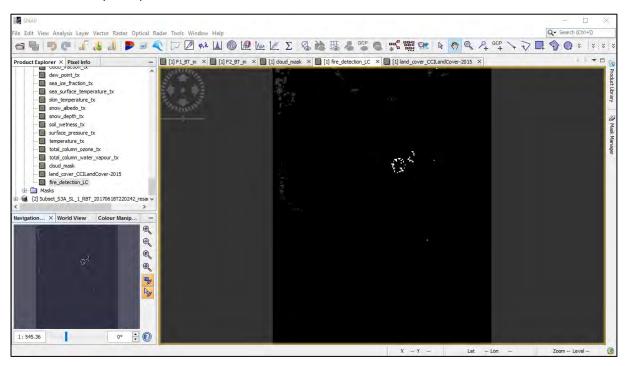
Deselect the "Virtual (safe expression only, don't store data)" option.

Then click "Edit Expression..." and enter the following conditions under Expression:

```
F1_BT_in > 325 and (F1_BT_in - F2_BT_in) > 18 and cloud_mask == 0 and
'land_cover_CCILandCover-2015' >= 50 and 'land_cover_CCILandCover-2015'
<= 130</pre>
```



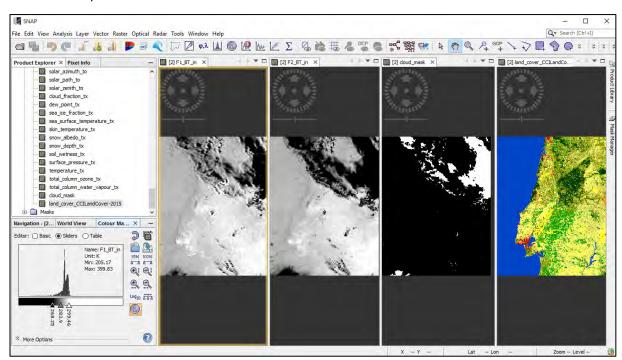
Click **OK** in both windows. The new band "**fire_detection_LC**" will be created and added in the **Bands** folder at the daytime product.



Go to Window \rightarrow Tile Single. In Navigation tab select Zoom all. Now, we can see the active fire pixels for 18 June 2017 at 10:45:48. To save our results, right-click the daytime product and select Save Product. Finally, close all our opened views.

7.4.2 Night-time fire detection

Now let's adapt our thresholds for the night-time image. First, let's open all our input bands to inspect them as we did for the daytime detection. Open and view the bands as at 7.4.1 Daytime fire detection chapter.



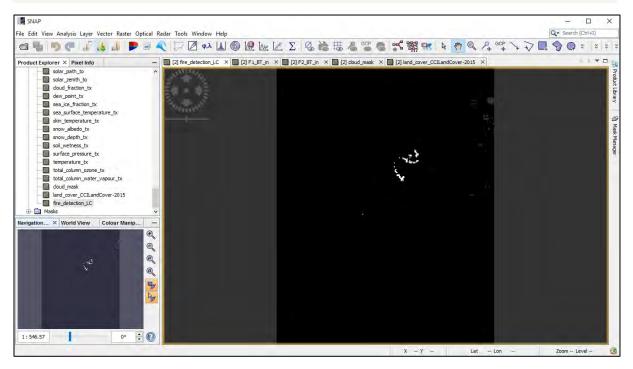
We can see that the distinction between the **BT** of land and ocean is not clearly visible during the night as it was during the day. We can also see some clouds covering over the area where we have detected the active fire pixels during the day. Use the **Pixel Info** tool again to explore the pixel values in our input bands. Think how you would change the thresholds we had used for the daytime detection.

The conditions for cloud mask and land cover will remain the same but due to the cooler background response during night, we need to slightly lower our thresholds. Let's set the initial test to 315 K and the warm background check to 15 K. Right-click the daytime product and go to **Band Maths...** A new window will open.

Set as Name: "fire_detection_LC"

Deselect the "**Virtual (safe expression only, don't store data)**" option. Then click **Edit Expression...** and enter the following conditions under "Expression":

```
F1_BT_in > 315 and (F1_BT_in - F2_BT_in) > 15 and cloud_mask == 0 and
'land_cover_CCILandCover-2015' >= 50 and 'land_cover_CCILandCover-2015'
<= 130</pre>
```



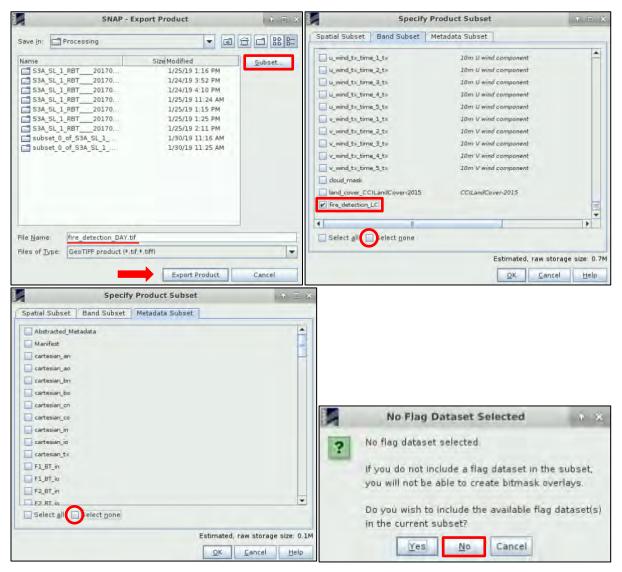
Go to Window \rightarrow Tile Single. In Navigation tab select Zoom all. Now, we can see the active fire pixels for 18 June 2017 at 22:02:42. To save our results, right-click the night-time product and select **Save Product**. However, in this case we need to be aware that some active cloud pixels could have been obscured by clouds. Close all view windows.

7.5 Export as GeoTIFFs

Open only the "*fire_detection_LC*" band of the day-time product. In **Product Explorer** tab, select (highlight) the daytime product.

Then go to File \rightarrow Export \rightarrow GeoTiff (NOT! Geotiff/Big Tiff). In the dialog, that opens click Subset \rightarrow Band Subset (second tab) and select only band "*fire_detection_LC*" (last in the list, use the Select none button to deselect all), then go to the Metadata Subset tab and click Select none. Click OK. In

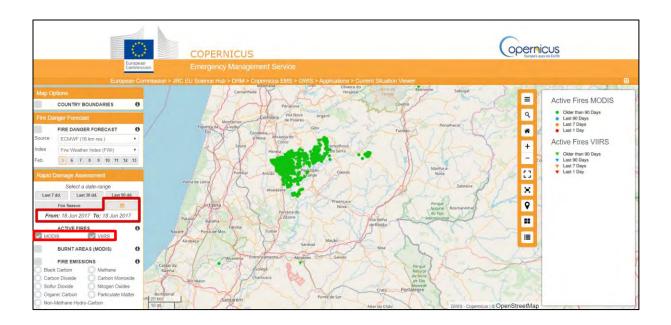
the dialog that appears, click **No** and save the file with the **File Name**: *fire_detection_DAY.tif* to the *Processing* folder by clicking on **Export Product**. Repeat the same for the night-time product (save as *fire_detection_NIGHT.tif*).



Now, we can import the image to another GIS/Remote sensing software for further processing or map creation (section **8.2 Convert to vector**). In the extra steps of this tutorial, we will use QGIS. To download the results to your local computer, see section **8.1 Downloading the outputs from VM**.

7.6 Compare results with operational monitoring

Now, you can compare your results with operationally derived products using different sensors such VIRS. MODIS Global Wildfire Information as etc. Go to System GWIS (http://gwis.jrc.ec.europa.eu/static/gwis current situation/public/index.html) and see how your result compares. Be aware that the site provides daily summary as compared to our product showing a snapshot in time. (Set: date-range from 18 June 2018 to 18 June 2017, select MODIS and VIRES and zoom in to the area of our interest).



THANK YOU FOR FOLLOWING THE EXERCISE!

8 Extra steps

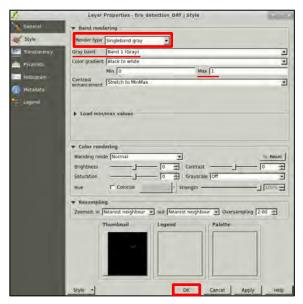
8.1 Downloading the outputs from VM

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 any file you want to download.**



8.2 Convert to Vector

Computer	Name /	Size	Туре	Date Modified
rus	S3A SL 1 RBT I resampled.data		Folder	1/24/19 4:10 PM
145	S3A SL 1 RBT548 radrefl.data		Folder	1/24/19 3:52 PM
	S3A SL 1 RBT L O NR 002.data		Folder	1/25/19 1:15 PM
	subset 0 of S3Areprojected.data		Folder	1/30/1:25 AM
	subset 0 of S3A reprojected.data		Folder	1/30/1:16 AM
	fire detection DAY.tif	5.1 MB	tif File	1/30/19 3:41 PM
	fire detection NIGHT.tif	4.9 MB	tif File	1/30/19 3:42 PM
	S3A SL 1 RBT reprojected.dim	5.3 MB	dim File	1/25/19 2:46 PM
	S3A SL 1 RBT4 resampled.dim			
	S3A SL 1 RBT VL O NR 002.dim	5.5 MB	dim File	1/25/19 1:15 PM
	S3A SL 1 RBT reprojected.dim	5.4 MB	dim File	1/25/1:25 AM
	S3A SL 1 RBTfl resampled.dim	5.3 MB	dim File	1/24/19 4:10 PM
	S3A SL 1 RBT4548 radrefl.dim	5.4 MB	dim File	1/24/19 3:52 PM
	S3A SL 1 RBT VL O NR 002.dim	11 KB	dim File	1/25/19 1:15 PM
	subset 0 of S3A reprojected.dim	5.3 MB	dim File	1/30/1:25 AM
	subset 0 of S3A reprojected.dim		dim File	1/30/1:16 AM
	•			



Go to Application \rightarrow Processing \rightarrow QGIS Desktop (or use the desktop icon).

Click on the Add Raster Layer , navigate to: /shared/Training/HAZA04_ActiveFire_Portugal_T utorialKit/Processing select the fire_detection_DAY.tif and click Open.

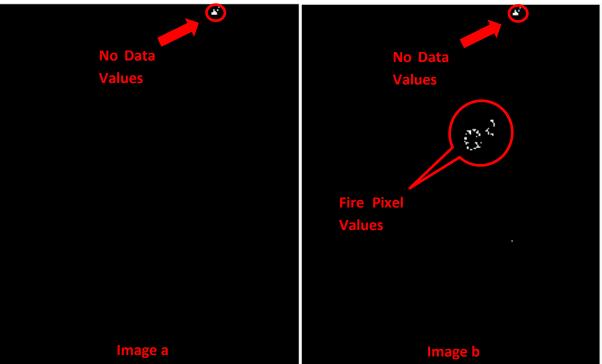
It will appear completely black (*Image a*), except for some No Data values which will appear in white. This happens because the No Data values are transparent, and our background is white. This means that if you set the background colour to a different one than white, e.g. red, the No Data values will appear red as well.

Right-click on the opened raster-layer in the Layers Panel (lower left) and go to Properties.

In the **Style** tab set:

Render type: Singleband gray Band: Band 1 (Gray) Max: 1

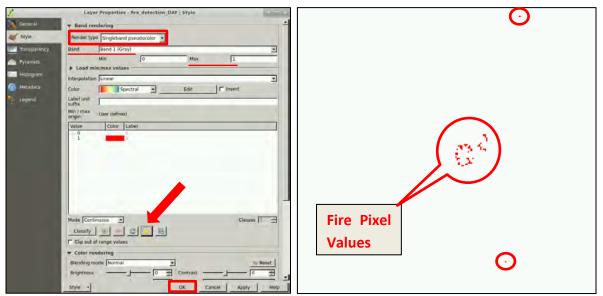
Click **OK** to see the fire pixel values at the band (they will appear in white, *Image b*).



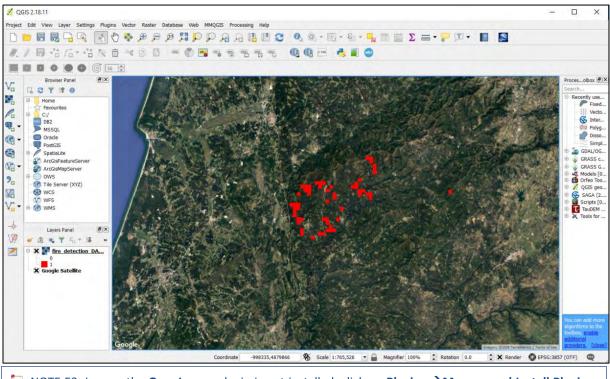
Right-click again on the opened raster-layer in the Layers Panel (lower left) and go to Properties.

In the Style tab set: Render type: Singleband pseudocolor Band: Band 1 (Gray) Max: 1

Then click **Load colour map from file** to import predefined colour map. Navigate to the *Auxdata* folder and open *Active_fire_no_background.txt*. Or design your own (fire pixels have value 1, background pixels have value 0). Click **OK**.



We can also add a base map layer. Go to Web \rightarrow OpenLayers plugin \rightarrow Google Maps \rightarrow Google Satellite. Drag the Google Satellite layer below the fire_detection layer in the Layers Panel (See \square NOTE E2).



NOTE E2: 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. Then go to **Processing** \rightarrow **Toolbox**, expand **GDAL/OGR**, then expand **[GDAL]** Conversion and double click the $\stackrel{\text{def}}{=}$ **Polygonize (raster to vector)** tool.

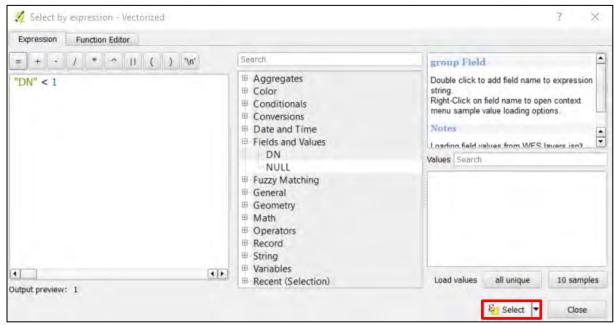
In the **Parameters** tab, check your input layer to be "fire_detection_DAY [EPSG:32629]", keep the "Output field name" as default and at "Vectorized" select "Save to file..." and save it at the *Processing* folder with "File name": "*fire_detection_DAY*")

Polygonize (raster to vector)
This algorithm is based on the GDAL gdal polygonize module.
For more info, see the module help

Click Run.

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						You can add more algorithms to the tablock, emable additional areaders, icluse)

You can see that the 0 values and No Data have been polygonised as well. We can remove them by right-clicking the Vectorized layer in the Layers Panel and going to Open Attribute Table. Then click Select features using an Expression" and enter "DN" < 1 (including quotation marks). Click at the lower right " Select" and then click Close.



All polygons except the ones with value 1 (fire) have been selected. Click **Edit** and then click **Emove.** This will remove all selected polygons.

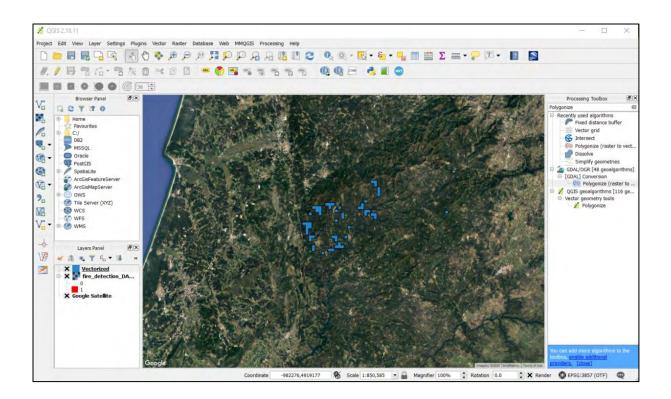
1	Vectorized :: Features total	103, filtered: 103, selected: 78		-	
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Now, click on **Edit** again to finish editing. Then click **Save** to save your edits. Close the Attribute Table.



Now we have a shapefile layer containing only our fire pixels.

You can repeat the 8.2 Convert to Vector chapter for the night band as well.



9 Further reading and resources

Global Wildfire Information System (GWIS) (<u>http://gwis.jrc.ec.europa.eu/static/gwis_current_situation/public/index.html</u>) Global Forest Watch - Fires (<u>http://fires.globalforestwatch.org/map/</u>)

CCI Land Cover (<u>http://maps.elie.ucl.ac.be/CCI/viewer/index.php</u>)

10 References

Giglio, L., Descloitres, J., Justice, C.O., and Kaufman, Y.J. (2003). An Enhanced Contextual Fire Detection Algorithm for MODIS. Remote Sens. Environ. *87*, 273–282.

Wooster, M.J., Xu, W., and Nightingale, T. (2012). Sentinel-3 SLSTR active fire detection and FRP product: Pre-launch algorithm development and performance evaluation using MODIS and ASTER datasets. Remote Sens. Environ. *120*, 236–254.

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