





# **TRAINING KIT – LAND08**

DEFORESTATION MONITORING WITH SENTINEL-2 Case Study: Paraquay, 2016-2018









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.

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Cover images produced by RUS Copernicus

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

Version: 1.2

Suggested citation:

Serco Italia SPA (2018). *Deforestation monitoring with Sentinel-2. (version 1.2).* Retrieved from RUS Lectures at <u>https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/</u>



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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 preinstalled on virtual machines, to handle and process data derived from the Copernicus Sentinel satellites constellation.



Deforested areas in Gran Chaco region, Credits: <u>https://www.hu-</u> <u>berlin.de</u>

Our study area for this exercise will be the part of the Gran Chaco forest in Paraguay. The Gran Chaco is a sparsely populated, hot and semi-arid lowland region of the Río de la Plata basin, laying partly in Bolivia, Paraguay, Argentina and Brazil. What has once been the largest continuous tropical forest on our planet has become the hotspot of deforestation in the last decade due to industrial scale cattle farming and soy production. It is estimated that one 1 hectare of forest is cleared every minute resulting in the destruction of this unique environment.

There is number of methods used for monitoring deforestation with satellite data. However, visual interpretation by a human operator is still broadly used and most accurate, many semi-automatic and automatic methods exist. Vast majority of these methods is based on classification algorithms. In the previous webinar (LAND07), you have heard about supervised classification method called "**Random Forest Classifier**", today we will use a very different method called "**Support Vector Machine**" (SVM).

# 2 Training

Approximate duration of this training session is two hours.

The Training Code for this tutorial is LAND08. 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  $\rightarrow$  Your dashboard.

#### 2.1 Data used

- Three cloud-free Sentinel-2 Level-1C tile (Tile ID: T20KQB) [downloadable @ https://scihub.copernicus.eu/]
  - S2A\_MSIL1C\_20160813T141052\_N0204\_R110\_T20KQB\_20160813T141049
  - S2B\_MSIL1C\_20170823T141039\_N0205\_R110\_T20KQB\_20170823T141404
  - S2A\_MSIL1C\_20180813T141051\_N0206\_R110\_T20KQB\_20180813T174352

#### 2.2 Software in RUS environment

Internet browser, SNAP + Sentinel-2 Toolbox, Sen2Cor, 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 (<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 *	
	Seattle
	News from RUS
	One year on!
	Copernicus Info Session - Reykjavik - 19 September 2018
To a series	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
	IGARSS 2018 - Valencia - 22-27 July 2018
Welcome to the Copernicus Research and User Support (RUS) Service portal!	<ul> <li>The RUS agenda</li> </ul>
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	CDS-SSO ID Password Max Idle Time Max Session Time	half a day Until browser close	¥	0 0 0
Users who already have a COPERNICUS SSO account can login here:		Login Forgot your password?	Reset	

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



# 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*.

User Support     The RUS Service * The RUS Offer * The RUS Library * The RU	IS Community • 👷 Your RUS servi	Hello, Miguel
Your RUS service	Your profile  Your dashboard  Your training	You are here: Home > Your RUS se
Fhis section gathers pages related to your RUS services:     Your profile: displays your personal information linked to your ESA SS     Your dashboard: Illows you to access your private dashboard,	50 and RUS accounts,	News from RUS One year on! Copernicus Info Session – Reykjavik – 19 September 2018 SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12
<ul> <li>Your training: allows you to register to a training session you have been been been been been been been be</li></ul>	en invited to participate in.	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	an ma se se	Hello, Miguel &
The RUS Service * The RUS Offer * The R	US Library • The RUS Community • 👫 Your RUS service •	
		You are here: Home > Your RUS service > Your dashboard
<ul> <li>Your dashboard</li> </ul>		0
Request a new User Service		Chat with Support Desk
Copyright © 2017 Research and User Support	c	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.

Step 1/3 Your experience	
Please help us learn more about your background by answering a information will be stored in your User Profile.	few questions. Th
How many years of experience in Remote Sensing do you have?	
Choose one Item	
Have you already downloaded Copernicus data via the Copernicus Open acces	is hubs?
® Yes	
© No	
Have you already handled/processed Copernicus data?	
W Yes	
© No	
Do you wish to practice a tutorial exercise shown in a RUS webinar? If yes, plea (hold down CTRL key for multiple selections).	se select your choice
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 abov its name or code. Note that you can request multiple tutorial exercises.	e list, please type here

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

outinities of the second second		
This is a collection of information selected	d 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?	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		
S1 - Polarisation		
S1 - Orbit direction		
Sentinel-2	X	
Sentinel-3	X	
Other	X	
I don't know	X	
Region of Interest:	10000	
Min Latitude	39.3303	
Max Latitude	40.58/7	
Min Longitude	-4.6/36	
Max Longitude	-2.7205	
Reference porygons		
Data acquisition date(s):		
None		
Additional data specifications		
I have read and agree to the Terms and	conditions of RUS Service	

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**  $\rightarrow$  **Your Dashboard** and click on **Access my Virtual Machine**.

							You are here: Home >	Your RUS service > Your dash
Your dashboard								
Request a new L	Jser Servi	ce					5	Chat with Support Desk
Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
	1	-		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	Report a technical

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.

Applications						1.2.2
ale System	(Refer		BIRAT Schuseblar	<b>()</b> 385	RESERVE	SNAP
	Commented Sta			Canada Ca	Lupy Kar Astabasiz	Address and
dibiQ2	(III) Trissie					
		opernicus				

## 5 Step-by-step

## 5.1 Data download - ESA SciHUB

In this step, we will download a Sentinel-2 scene from the Copernicus Open Access Hub using the online interface (**Applications**  $\rightarrow$  **Network**  $\rightarrow$  **Firefox Web Browser** or click the link below).

Go to <a href="https://scihub.copernicus.eu/">https://scihub.copernicus.eu/</a>



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



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

Then navigate to the north of Paraguay, approximately as indicated on map below and switch the base layer to Sentinel-2 cloudless overlay.

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Boyuthe		A A A
Macharet		Luete Filmer
Villamontes		Bonto
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cuiba	Mariscal Estigarritia	Valtering with the Bela Vista
-56.6765, -20.7639	filadellia Loma Plata	Note O

Now we have two options either we can switch to the rectangle-drawing mode (Green arrow) and draw search polygon over our study area (approximate area – orange rectangle) or we can specify the Sentinel-2 tile we are looking for in the Search text box (Purple arrow). The tile identification consists of UTM zone number and 3 letter code. We can find it in the name of any product from the same location we already have. For us the code is **20KQB**. We enter it to the search filed as **\*20KQB\***.

Sensing period: Check Mission: Cloud Cover %: From 2016/08/13 to 2018/08/13 Sentinel-2 [0 TO 10]

		Copernicus Open Access Hub	20 🕈
≡ *20КQВ*	8	9	
	/×		
Sensing period From: 20	116/08/13 🖬 to: 2018/08/13 🖬	A CARLEND AND A CARLEND	
Ingestion period From: Mission: Sentinel-1	to:		
Satellite Platform	Product Type		
Polarisation	* Sensor Mode		
Relative Orbit Number (from 1 to 175)	Collection		3
Mission: Sentinel-2	•	C H	
Satellite Platform	Product Type	BT .	
Relative Orbit Number (from 1 to 143)	Cloud Cover % (e g [0 TO 9.4])		
O Mission: Sentinel-3	[0 TO 10]	TO T	
Satellite Platform	Product Type		lean and
Timeliness	Instrument		The and
THE REPORT	The unit of the second se	State State - State State State	0
s://sentinel.esa.int		AND AND AN ADDRESS AND ADDR	

Then click **Search** . In our case, the search returns 27 results as we are looking at long time period. Now let's find following three products and add them to cart using the symbol as shown below:

S2A\_MSIL1C\_**20160813**T141052\_N0204\_R110\_T20KQB\_20160813T141049 S2B\_MSIL1C\_**20170823**T141039\_N0205\_R110\_T20KQB\_20170823T141404 S2A\_MSIL1C\_**20180813**T141051\_N0206\_R110\_T20KQB\_20180813T174352



Once all our data are in the cart, click on the **Profile** icon in the upper right corner (marked with **green circle** above) and go to **Cart**. You should now have three products in your cart. Click **Download Cart**.

📬 🕼 🕼 esa 🛛 opermicus	Copernicus Open Access Hub	<b>± 0 †</b>
	Your cart contains 3 products. Display 1 to 3 of 3 products.	<u></u>
SZA MSI S2A_MSIL1C_20180B13T141051_N0206_R110	T20KQB_20180813T174352	
Download URL: https://scihub.copernicus.eu/dhu Mission: Sentinel-2 Instrument: MSI Sensing Da	sr/sdafu/r/FP-ook/sdqf19893556-372-40a-8444-f695369666aa/)Svalue Ite: 2018-08-13714-10.51.024Z Size: 778.33 MB	
52A MSI S2A_MSIL1C_20160813T141052_N0204_R110	T20KQB_20160813T141049	
Download URL: https://scihub.copernicus.eu/dhu Mission: Sentinel-2 Instrument: MSL Sensing Du	schadar/v1FP-oxlumbr/11f5-2748-3789-1485-ai/27-0-147aetff5811)Svalue the 2016-08-13714-10-52 0262 Size: 752-80 MB	
S28 MSI S2B_MSIL1C_20170823T141039_N0205_R110	T20KQB_20170823T141404	
Download URL https://sofula.copernicus.eu/dhu Nasion: Sentinel-2 Instrument: MSI Sensing Dr	s/oala/v/MHodicts(*3/3168-6276-600-804-56812/5/300a)ssvalue le: 2017-08-23114-10.39.0272 Size: 784.02 MB	
Products per page: 25 * Page#: 1 of 1		DOWNLOAD CART

A *products.meta4* file will be downloaded to your */home/rus/* folder. To download our data, we will use **aria2** tool. To use the tool, we first need to place the *products.meta4* file to the folder where we wish our data to be downloaded to:

#### /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Original/

Let's test our aria2 installation. To do this we open the Command Line in the bottom of your desktop window), type the following and then press "Enter": aria2c

The correct response should be as follows:



If the response is "-bash aria2c: command not found" (see 🛄 NOTE 1).

NOTE 1: If (and only if) the response is "-bash aria2c: command not found". Then we have to install the tool, to do this in command line type: sudo apt-get install aria2 When requested type: Y Then you can test your installation again.

If you have received the correct response, then we can run the tool by typing following commands in the command line (replace **<username>** and **<password>** with your login credentials for Copernicus Open Access Hub):

First type the following command and press "Enter". It defines our target directory.

cd /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Original/

Then type the following command and after having made the necessary changes press "Enter" to run the download tool (Type the red text all in single line).

```
aria2c --http-user='<username>' --http-passwd='<password>' --check-
certificate=false --max-concurrent-downloads=2 -M products.meta4
```

All three products will be downloaded to the *Original* folder two products in parallel automatically (Note that the constraint of maximum two parallel downloads at a time is imposed by the Copernicus Access Hub, if you increase the number the download will fail). This might take some time.

Lastly, navigate to the folder where our data are saved: */shared/Training/LAND08\_Deforestation Monitoring \_S2\_TutorialKit/Original* and unzip all three products by right-clicking each and going to *"Extract Here"*.

	Original - File Manager	* = ± ×
File Edit View Ge	<ul> <li>Help</li> <li>/shared/Training/LAND08_DeforestationMonitoring_52_TutorialKit/Original/</li> </ul>	C
DEVICES	Name	7
PLACES	<ul> <li>S2A_MSILIC_20160813T141052_N0204_R110_T20KQB_20160813T141049.SAFE</li> <li>S2A_MSILIC_20180813T141051_N0206_R110_T20KQB_20180813T174352.SAFE</li> <li>S2B_MSILIC_20170823T141039_N0205_R110_T20KQB_20170823T141404.SAFE</li> </ul>	
Desktop	<ul> <li>products.meta4</li> <li>S2A_MSIL1C_20160813T141052_N0204_R110_T20KQB_20160813T141049.zip</li> <li>S2A_MSIL1C_20180813T141051_N0206_R110_T20KQB_20180813T174352.zip</li> <li>S2B_MSIL1C_20170823T141039_N0205_R110_T20KQB_20170823T141404.zip</li> </ul>	

#### 5.2 SNAP – open and explore data

Launch SNAP (icon on desktop ). When the SNAP window opens click **Open Product** , navigate to: */shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Original* and open the three zipped downloaded S2 products (SNAP can read .ZIP files).

Right-click the product from 2018 and click **Open RGB image window**, a new window will open. From the drop-down menu select:

Profile: Sentinel 2 MSI Natural Colors

Click **OK**. The RGB image will be opened at the **View** window.



#### 5.3 Atmospheric correction

The "Level 1C" data we have downloaded are radiometrically and geometrically corrected (including orthorectification and spatial registration). However, atmospheric correction is applied only to the Level 2A data which are not available for our study site at this time.

TIP: Level 2A have been systematically produced for newly acquired products over Europe since the spring of 2017, the coverage has been increasing through 2018 to reach global coverage in the beginning of 2019.

Solar radiation reflected by the Earth's surface to satellite sensors is affected by its interaction with the atmosphere. The objective of applying an atmospheric correction is to determine true surface (Bottom-Of-Atmosphere, BOA) reflectance values from the Top-Of-Atmosphere (TOA) reflectance values, by removing atmospheric effects. (See  $\square$  NOTE 1) Atmospheric correction is especially important in cases where multi-temporal images are compared and analysed as it is in our case. <sup>1</sup>

In this tutorial, we will use the Sen2Cor processor. Sen2Cor is a processor for Sentinel-2 Level 2A product generation and formatting; it performs the atmospheric, terrain and cirrus correction of Top-Of-Atmosphere Level 1C input data. Sen2Cor creates Bottom-Of-Atmosphere, optionally terrain and cirrus corrected reflectance images; additional, Aerosol Optical Thickness, Water Vapour, Scene Classification Maps and Quality Indicators for cloud and snow probabilities.





Go to Optical  $\rightarrow$  Thematic Land Processing  $\rightarrow$  Sen2Cor.

In the **I/O Parameters** tab, click on "…" next to the product name and navigate to the **Original** folder. Open the ".**SAFE**" folder of the 2016 product. Then open the **MTD\_MSIL1C.xml** file. In the **Processing Parameters** tab change the resolution to "**ALL**" and select "**Display execution output**". Click **Run**.

	SEN2COR	* E X		SENZCOR	1.2.3
File Help			File Help		
I/O Parameters	Processing Parameters		I/O Parameters	Processing Parameters	
Source Product			Display execution	n output	
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		Select Cancel	1 <u></u>		<u>Bun</u> <u>Close</u> <u>H</u> elp

This is rather a time demanding process and requires approximately 30 minutes per image (with 8GB RAM). Repeat for products [2] and [3]. Close **Sen2Cor** window when all processing is completed.

You will see three new products created at the **Product Explorer** window, named "**Output Product**". Select them all, right click on them and select "**Close 3 Products**". Click "**No**" to the following windows that will appear.

Produ	ct Explorer × Pixel	info 🔲
- 8	[1] S2A_MSIL1C_20	160813T141052_N0204_R110_T20KQB_20160813T14104
- 8	[3] S2A_MSIL1C_20	L80813T141051_N0206_R110_T20KQB_20180813T17435
0	[4] Output Product	
0	[5] Output Product	
0	[6] Output Product	

This process creates three new Level 2-A products in the *.SAFE* format in the *Original* folder. Move them to: */shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Original/Level-2A* 

Now let's load the results to SNAP.

Click **Open Product** 🖾, navigate to:

/shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Original/Level-2A and open the Level-2A product folder for 2016:

#### S2A\_MSIL2A\_20160813T141052\_N0204\_R110\_T20KQB\_20160813T141049.SAFE

Open the *MTD\_MSIL2A.xml*. Repeat the same for the Level-2A products from 2017 and 2018.

In the **Product Explorer** window, right-click the Level-2A product from 2018 and click **Open RGB image window**, a new window will open. From the drop-down menu select:

Profile: Sentinel 2 MSI Natural Colors

Then go to Window → Tile Horizontally to compare the L1C and L2A products side by side.



In this case there is not much visible difference, but we can now be reasonably sure that the values in our three images are comparable and correspond to the reflectance of the objects on the ground.

Now in the **Product Explorer** window, select the L1C products ([1] - [3]), right-click and go to "**Close 3 products**", as we will not need them anymore. Click "**No**" to discard changes to the products.

#### 5.4 Resample, subset & calculate

To avoid processing the data step-by-step we will use the Graph Builder.

Go to **Tools**  $\rightarrow$  **GraphBuilder**. So far, the graph only has two operators: **Read** (to read the input) and **Write** (to write the output).

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	Source Product	LICENSE CONTRACTOR
	[4] 52A_MSH.2A_20160813T141052_N0204_R110_T20K08_20160813T241049	
	Data Format Anv Format	
	La la	
		and the second s
	Print Brans Schart Bland Build Domain	
	Press 2 Dave Driese IN unite & ueb D you	
		X - Y - Lat - Lon - Zoom - Lovel -

The 13 bands in Sentinel-2 products do not all have the same resolution (therefore size) as mentioned in  $\frown$  NOTE 2. Many operators do not support products with bands of different sizes, so we need to resample the bands to equal resolution first. To add the operator right-click the white space between the existing operators and go to Add  $\rightarrow$  Raster  $\rightarrow$  Geometric  $\rightarrow$  Resample.

NOTE 2: The input product contains 13 spectral bands in three different spatial resolutions (The surface area measured on the ground and represented by an individual pixel). When we open the RGB view all our input bands have 20 m resolution, however, the view is displayed in the full 10 m resolution.



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



Next step will be to subset the images to the area of interest. We do this by right-clicking the white space somewhere right of the resample operator and going to Add  $\rightarrow$  Raster  $\rightarrow$  Geometric  $\rightarrow$  Subset. Connect the Subset operator with the Resample operator.

Now, we will add the **BandMerge** operator from Add  $\rightarrow$  Raster  $\rightarrow$  BandMerge and connect it to the Subset operator.

Then, we add the **BandMaths** operator from Add  $\rightarrow$  Raster  $\rightarrow$  BandMaths. Now connect the **BandMaths** operator with the **Subset** operator and then connect it to the **BandMerge** operator as well. Then connect the **BandMerge** operator with the **Write** operator.



For each of our operators a tab has appended in the bottom of the graph. Do not change any parameters in the tabs at the moment. Click **Save** at the bottom of the window and save the graph as *Graph\_preprocess.xml* in:

#### /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing

Now, we can close the **Graph Builder** window and open the **Batch Processing** tool (**Tools**  $\rightarrow$  **Batch Processing**). Now we will set our processing parameters for each operator.

In the **I/O Parameters** tab, we will add all three opened products by clicking **Add Opened** and the upper right (second from top). Click **Refresh** a. Unselect the **Keep source product name**. Then, click **Load Graph** at the bottom of the window, navigate to our saved graph and open it. We see that new tabs have appeared at the top of window corresponding to our operators.

		Write	BandMerge	BandMaths	Subset	Resample	arameters
Add opene	+	Orbit 99999	Track 99999 99999	Acquisition 13Aug2016 23Aug2017	Type MSI_Lev MSI_Lev	813T S2_ 823 S2	File Name ISIL2A_2016 ISIL2A_2017
	*						151L2A_
Refresh							
Refresh	3 Products						et Folder
Refresh	3 Products				-	1 -	et Folder
Refresh	3 Products				-		et Folder as:

Finally, we can set the parameters.

In Resample tab we set:

**Define size of resampled product:** By reference band from source product: **B11** (we will resample all the bands to 20 m resolution).

Downsampling method: Mean

Define size of resampled product	
	811
By reference band from source product.	Resulting target width: 5490
	Resulting target height: 5490
	Target width: 10,980
By target width and height:	Target height: 19,380
	Width / height ratio: 1.00000
	1. And
O By pixel resolution (in m):	Resulting target width 1098
	Resulting target height 1098
psampling method	Nearest
ownsampling method	Mean
ag downsampling method	First
Pasampla on puramid lavals (for factor im)	para l

In the Subset tab, we select bands: B4, B8, B11 and B12 (to select multiple hold Ctrl).

Make sure the **Pixel Coordinates** option is selected and then set:

#### **Width:** 5940 **Height:** 5940

	Batch Proces	sing : Graph_preprocess.	xml	* 3 *
File Graphs				
I/O Parameters	Resample Subs	set BandMaths BandMerg	e Write	
Source Bands:	85 86 87 88 88A 89 811 812			
Copy Metadata	es 🔘 Geographic (	Coordinates		
X:	0	Y:	0	
Width:	5940	height	5940	
Sub-sampling X	1	Sub-sampling Y:	1	

To create additional information for our classification we will calculate the <u>N</u>ormalized <u>D</u>ifference <u>V</u>egetation <u>Index (NDVI)</u> – developed by Rouse<sup>2</sup>, the NDVI algorithm exploits the strength and the vitality of the vegetation on the earth's surface. It indicates amount of vegetation, distinguishes vegetation from soil and minimizes topographic effects. NDVI is calculated as :

$$NDVI = \frac{NIR - Red}{NIR + Red} = \frac{B8 - B4}{B8 + B4}$$

We define the expression for the calculation of NDVI in the **BandMaths** tab: **Target band:** NDVI **No-Data Value:** 0.0 Click on **Edit Expression** and set: (B8 - B4)/(B8 + B4)

Batch Processing : Graph_preprocess.xml = = =	Ari	thmetic Expression Edit	or EX
File Graphs	Data sources: B4	0 + 0	Expression: (B8 - B4)/(B8 + B4)
VO Parameters Resample Subset BandMaths BandMerge Write Target Band: NDVI	B8 B11	0 - 0	
Target Band Type: float32	812	@ * @	
No-Data Value: 0.0		(@)	-
Expression:		Constants	
	Show bands	Operators 👻	
Edit Expression	Show pe-point grids	Functions	
Load Graph Run Close Help		C	<u>QK</u> <u>Cancel</u> <u>H</u> elp

Then click **OK**.

Now we need to add the NDVI band to our original subset using the **BandMerge**. We will not change anything in the **BandMerge** tab, use the default settings.



In the **Write** tab check that the name contains "20160813" (or the date of the first loaded image) but do not change anything. Then set **Save as:** GeoTIFF

# Set the output directory: /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing

4	Batch P	rocessing	Graph_pr	eprocess	amt	6	+ = x
le Graphs							
I/O Parameters	Resample	Subset	BandMaths	BandMe	erge Writ	te	
Target Product							
Name: Subset_S2A_MSI	L2A_2016081	37141052	N0204_R110_	T20KQB_20	160813T14	1049_resam	pled
Save as: GeoTIF	F						
Directory:		Defensetek		00 T. 4-6-	In the second second	-	
/shared/train	hing/LAND08_	Deforestation	onMonitoring_	S2_Tutorial	Kit/Process	sing	414
					-		

Finally, let's click **Run.** This might take a few minutes depending on your machine.

Now, you should have three new products in the **Product Explorer** window. Close the **Batch Processing** window and all the **View** windows and expand the first new product [7]. In **Bands** folder, double-click

the NDVI band. Now do the same for the other two products ([8] and [9]) as well. Go to Window  $\rightarrow$  Tile Horizontally and then in Navigation tab, click Zoom All  $\overset{@}{=}$ .

To be able to compare the images better, we can apply the same stretch to all Views. We can do this by applying the same histogram stretch. Select the first View [7] and go to **Colour Manipulation** tab, here we can see the histogram. Click **Apply to other bands**, in the menu of the window that appears, select only **[8] NDVI** and **[9] NDVI**, then click **OK**. Click "**No**" in the next dialogs.



Now we can move to QGIS to start the classification. Close **SNAP** and click "**No**" to the pop-up window.

#### 5.5 Classification in QGIS

Let's open QGIS  $\mathscr{A}$ . Go to Application  $\rightarrow$  Processing  $\rightarrow$  QGIS Desktop. In the Browser Panel we navigate to */shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing* and load the three GeoTIFF products we have created in SNAP (hold CTRL, select all 3 layers and drag them to the Layers Panel).



A good training dataset is very important for the accuracy of any classification. Here it has already been created for you, using the image from 2016 to create training polygons for deforested areas and the image from 2018 to create training polygons for forest. If you wish to create your own see 1 NOTE 3.



When the new empty layer is created you can right-click the layer and select "**Toggle editing**", then select **\*\* \*\*Add feature".** You can then start drawing by clicking on the image and you can close polygon by right-click, then you must set the field values. When you are done with all polygons for both classes, click the **\*\*Toggle editing**" again to save edits. (**Remember**: Class: forest – Class\_ID: 1, Class: non-forest – Class\_ID: 2).



In this way we have single training dataset for all three images as we can assume that that if an area was forest in 2018 it must have been forest also in 2016. Of course, training data created over high resolution imagery or even in situ training data would be invaluable and may improve the accuracy of our classification.

Now we load the training dataset that is already provided. In the **Browser panel** navigate to: /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/AuxData Load: Training\_data.shp

Then, right-click the layer and go to **Properties**  $\rightarrow$  **Style** to change the appearance. Click **Style**  $\rightarrow$  **Load Style**, then navigate to the *AuxData* folder and select *Training\_data.qml*. Then click **OK**.

1	Layer Properties - Training_data   Style	• = ×
General	Categorized	x
💞 Style	Column abe Class	3
abc Labels	Symbol Chai	nge
Fields	Color ramp Random colors	Edit F Invert
Rendering Display Actions Joins Diagrams Metadata	Symbol  Value Legend  Forest Forest  Non-Forest Non-Forest	
Variables Legend	Classify  Delete all Load Style	Advanced +
	Save Style  Save as Default Restore Default Add Rename Current ring order	0 <u>*</u>

Now we can start with the classification. We will be using the **dzetsaka** stool to train our classifier (build a model) and classify our images. You can find it in the **Processing Toolbox** window on the right (See NOTE 4).

This plugin has by developed by Nicolas Karasiak, for work in the Amazon, it simplifies classification algorithms and automatically determined the best parameters to be used.

NOTE 4: In case the dzetsaka plugin is not installed, click on Plugins → Manage and Install Plugins. Select the "All" tab on the left side panel and write "dzetsaka" on the search box. Select the plugin on the list and click "Install Plugin". You may need to restart QGIS to finalize the installation. To find out more about the plug-in go to <u>https://github.com/lennepkade/dzetsaka</u> A Scikit-learn library is also required to run the plug-in. It can be installed from command line by running following line: python2.7 -m pip install scikit-learn --user

#### 5.5.1 Build Model

First, we need to train our classifier using the vector training dataset. In our training data, we have defined 2 classes: Forest (Class\_ID: 1)

Non-forest (Class\_ID: 2)



Go to the **Processing Toolbox** and expand the **dzetsaka** group. Double click on the **Train algorithm** tool. The tool menu will open, allowing us to process a single image. However, we have 3 images to process so we can select the Batch processing mode (**Run as batch process**...) at the top right side. Below you can see the menu pre-set for processing one of our images.

We can choose from 4 classifiers, in this example we will be using the **Support Vector Machine (SVM)** classifier (See NOTE 5). Generally, many settings are required to run SVM but **dzetsaka** is a simplified tool that estimates the best parameters for us and allows us to get good results without needing to have much knowledge of the algorithm. Note that we are keeping only 50% of the training samples (pixels within our training polygons) to train the model. The other 50% is used to generate a confusion matrix (See NOTE 6). Click on "**Run as batch process**...".

	Train algorithm	* E (
Parameters Log		Run as batch process
Input raster		
Subset_S2A_MSIL2A_20160813T141052_N020	04_R110_T20KQB_20160813T141049_resampled [EPSG:32720]	•
Input layer		
Training_data [EPSG:32720]		2 9
Field (column must have classification number	(e.g. '1' forest, '2' water))	
Class_ID		
Select algorithm to train		
Support Vector Machine		
Pixels (0.5 for 50%) to keep for classification		
0.500000		
Output model (to use for classifying)		
/home/rus/shared/Training/Webinars/LAND09_	Deforestation_S2_TutorialKit/Processing/Classification/Model_SVM_2016.txt	
Output confusion matrix		
/home/rus/shared/Training/Webinars/LAND09_	Deforestation_S2_TutorialKit/Processing/Classification/CFMatrix_SVM_2016.csv	r
		0%
		Pun Close

We do not need to set any parameter in this window since we will use "*Run as batch process...*" where will set the parameters/load file containing pre-set parameters.

# Then click on and load the prepared settings from **QGIS\_Batch\_TrainModel.json** in: /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/AuxData

Find the column called **Select algorithm to train** and set *"Support Vector Machine"* for all three instances. After the processing is completed, check that three new text files have been created in the */Processing/Classification/* folder (See NOTE 7).

Input raster	Input layer	assification number	elect algorithm to tra	or 50%) to keep for c	model (to use for c	las utput confusion mate	Load in QGIS
R110_T20KC	Training_data	Class_ID	Support Vector Mach 🔹	0.5	Kit/Processin	Processing/Cl	Yes
R110_T20KC	Training_dati	Class_ID	Support Vector Mach 🔹	0.5	Kit/Processin	Processing/Cl	Yes
R110_T20KC	Training_dati	Class_ID	Support Vector Mach 🝷	0.5	Kit/Processin	Processing/Cl	Yes

Click Run. This may take up to 45 minutes.

1	Batch Processing - Train algorithm	1 B B B
Parameters Log		
Processing algorithm 1/3 Algorithm Train algorithm starting Converting outputs Loading resulting layers Algorithm Train algorithm correctly executed Processing algorithm 7/3 Algorithm Train algorithm starting Converting outputs Loading resulting layers Algorithm Train algorithm correctly executed Descence a burstlen 2/0		
Processing algorithm 3/3 Algorithm Train algorithm starting Converting outputs Loading resulting layers Algorithm Train algorithm correctly executed		
Loading resulting layers		
		0%
		Run Close

Close the Batch Processing and Train Algorithm windows.

NOTE 5: The Support Vector Machine (SVM) algorithm translates (plots) the data points to ndimensional space with the values of different input features/raster bands acting as coordinates. The objective of the support vector machine algorithm is to find a hyperplane in this N-dimensional space (N — the number of input features) that distinctly classifies the data points into two classes.

To separate the classes of data points, there are many possible hyperplanes that could be chosen. Our objective is to find a plane that has the maximum margin, i.e the maximum distance between data points of both classes. The Support vectors are the data points close to the hyperplane that influence its position. (Rohith Gandhi, https://towardsdatascience.com/)



NOTE 6: A confusion matrix is a table that is used to describe the performance of a classification model (or "classifier") on a set of test data for which the true values are known.

NOTE 7: Make sure that there is already created the */Classification* folder in the */Processing* folder. If no, create it by yourself and then continue with the following steps.

#### 5.5.2 Classify image

Next, we will apply the model to classify the images. Go to the **Processing Toolbox** and expand the **dzetsaka** group. Double-click on the **Classify model** tool.



Go to **Run as batch process...** again and click on and load the prepared settings from: /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/AuxData/QGIS\_Batch\_Classifi cation.json

	Classify model	( + E )
Parameters Log		Run as batch process
Input raster		
Subset_S2A_MSIL2A_20160813T141052_N0204_	R110_T20KQB_20160813T141049_resampled [EPSG:32720]	×
Input mask [optional]		
[Not selected]		·
Input model [optional]		
/home/rus/shared/Training/LAND08_Deforestation	nMonitoring_S2_TutorialKit/Processing/Classification/Model_SVM_20	016.txt
Output raster (classification)		
/home/rus/shared/Training/LAND08_Deforestation	nMonitoring_S2_TutorialKit/Processing/Classification/Classification_	SVM_2016.tif
Open output file after running algorithm		

Input raster		Input mask	Input model	Output raster (classification	on)	Load in	QGIS
4_R110_T20KQB_201608:			pdel_SVM_2016.txt	cessing/Classification/Classificatio		Yes	
5_R110_T20KQB_201708:	ff		pdel_SVM_2017.txt .	essing/Classification/Classification		Yes	
5_R110_T20KQB_201808			pdel_SVM_2018.txt .	essing/Classification/Classification		Yes	
1					1		

Then click Run. This may take up to 10 minutes.

**NOTE!** If QGIS fail to run the process, set in the Batch Processing all the parameters manually.

Go to Run as batch process... and set:

In the "Input raster" select the three .tif images from: shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing path:

- Subset\_S2A\_MSIL2A\_20160813T141052\_N0204\_R110\_T20KQB\_20160813T141049\_resampled.tif
- Subset\_S2B\_MSIL2A\_20170823T141039\_N0205\_R110\_T20KQB\_20170823T141404\_resampled.tif
- Subset\_S2A\_MSIL2A\_20180813T141051\_N0206\_R110\_T20KQB\_20180813T174352\_resampled.tif

In the "Input model" select the three .txt files from: shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing/Classification path:

- Model\_SVM\_2016.txt
- Model\_SVM\_2017.txt
- Model\_SVM\_2018.txt

In the "Output raster (classification)" save each image in:

*shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing/Classification* with the following names:

- Classification\_SVM\_2016.tif
- Classification\_SVM\_2017.tif
- Classification\_SVM\_2018.tif

Then click **Run**.

Three new raster files have appeared in our **Layers Panel** tab. They are however all named **Output** ... so we will close them and reload them again with the correct names. In the **Browser Panel** tab, navigate to the **/Classification** folder and open the three raster-layers.



Then let's visualize them better. Right-click on the first layer (classification from 2016) and go to **Properties**.

In the Style tab select:

Render type: Singleband pseudocolor

Band: Band 1 (Gray)

Then in the bottom go to **Load colour map from file**, navigate to the **Auxdata** folder and select **Classification\_2016\_colour\_palette.txt**. Click **OK** and do the same for the other two classified layers using the respective colour palettes.

1		ayer Properties - Classification_SVM_2016   Style	+ E ×	
🔀 General	- Band r	ndering	-	
💐 Style	Render ty	e Singleband pseudocolor +		
Transparency	Band	Band 1 (Gray)	2	
Pyramids		Min 1 Max 2		
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Langed	Color Label unit	Edit I invert		
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	Value	Color Label		
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Processing     Classific     Processing     Classific     Processing	cation		Ecarming and Cossil	y moth algorith
	atrix_SVM_2C atrix_SVM_2C		III vector manipul III 1 GOAL/OGR 14 III 1 GRASS GIS 7 III 1 GRASS GIS 7	i8 geoa comm.
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Classification SVM	2016			
Classification_SVM	2017			
Classification_SVM	2018			
Forest				
Non-Forest Subset S2A_MSIL2 Subset S2B_MSIL2	A_2016081 A_2017082			
Subset_S2A_MSIL2	A_2018081		thu tao and more a	gormo
3 legend entries removed.		Coordinate 747733,7644489 🗞 Scale 1:681,912 • Magnifier 100%	Rotation 0.0	(clea



Investigate the classifications visually compared to the natural composite images. You can turn the layers on and off in the Layers Panel.

The **dzetsaka** tool has also produced a simple confidence matrix for each classification. We can open it from the file explorer when we go to:

#### /shared/Training/LAND08\_DeforestationMonitoring\_S2\_TutorialKit/Processing/Classification

There you can find 3 files named *CFMatrix\_2016\_SVM.csv*, *CFMatrix\_2017\_SVM.csv* and *CFMatrix\_2018\_SVM.csv* 

Note that these confusion matrices are generated using the second half of our training data and therefore cannot be considered independent. If we truly want to assess the performance, we would have to create new independent validation dataset and compute additional statistics.

Classification 2016			Class	sification	2017	Classification 2018		
True value	Classified as forest	Classified as non-forest	True value	Classified as forest	Classified as non-forest	True value	Classified as forest	Classified as non-forest
forest	201404	9	forest	201402	3	forest	201395	12
non-forest	0	30237	non-forest	2	30237	non-forest	9	30234

# THANK YOU FOR FOLLOWING THE EXERCISE!

## 6 Extra steps

#### 6.1 Downloading the outputs from VM

On your keyboard, press **Ctrl+Alt+Shift.** A pop-up window will appear on the left side of the screen. Click on the 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**.

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Clipboard Text copied/rut within Guaca the text below will affect the r	mole will appear here. Changes to remote clipboard.		Berginsen B	
Devices				Seaso Seaso Seaso
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Allow typing of text, and em keyboard events based on th text. This is necessary for the mobile phones that lack a ph keyboard.	subate the typed evides such as hysical		Bat	
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## 7 References and resources

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