





TRAINING KIT – LAND01

CROP MAPPING WITH SENTINEL-2 JULY 2017, SPAIN









Research and User Support for Sentinel Core Products

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1 Introduction to RUS

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

In this tutorial we will employ RUS to identify and map different crops in an agricultural area near Seville (Spain) using Sentinel-2 satellite-borne optical data.

2 Crop mapping – background



Aerial view of the Guadalquivir marshes area.

The Guadalquivir Marshes represent one of the last territories occupied by man in the Spain's region of Andalucía. Settlements were not definitive until the 1940 decade, when the expansion of agriculture, especially rice, led a complete transformation of the area. Nowadays, 35.000 ha are used to grow rice with an average production rate of 8.500-10.000 kg/ha. Other crops such as wheat, cotton, sugar beet, or sunflower can be found as well.

Reliable information on crops is required to improve agricultural management and reduce the environmental impact of this activity. Different methods can be used to gather this information but satellite earth observation techniques offer a suitable approach based on the coverage and type of data that are provided. The imagery data from Sentinel satellites enables a new approach for agriculture monitoring. The combination of their temporal, spatial, and spectral resolutions together with relevant analysis can lead to improvements of the decision-making process.

3 Training

Approximate duration of this training session is one hour.

The Training Code for this tutorial is LAND01. 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 > Your dashboard.

3.1 Data used

 One Sentinel-2A level 2A image acquire on 01 June 2017 [downloadable at @ https://scihub.copernicus.eu/]

S2A_MSIL2A_20170601T110651_N0205_R137_T30STG_20170601T111225

Pre-processed data stored locally
 @/shared/Training/LAND01_CropMapping_Seville/AuxData/

3.2 Software in RUS environment

Internet browser, SNAP + Sentinel-2 Toolbox + QGIS

4 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	login / Register 🛔
The RUS Service * The RUS Offer * The RUS Library * The RUS Community *	
	sewsh
	★ News from RUS
	One year on!
	Copernicus Info Session – Reykjavik – 19 September 2018
	SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12 September 2018
	SIWI World Water Week 2018 - Stockholm - 26-31 August 2018
	MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018
	RUS Webinar - Special edition "AskRUS - Sentinel-1" - 12 July 2018
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!	▼ 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 e-mail 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 thrid email sent by the Copernicus vertice. We advise you to consult this document and this page to facilitate your registration procedure. REGISTER COPERNICUS SSO account Users who already have a COPERNICUS SSO account can login here: Login	CDS-SSO ID Password Max Idle Time Max Session Time	half a day Until browser close Login Reset	v	000000000000000000000000000000000000000
Close		Forgot your password?		

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

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5 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	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community * Store Your RUS A Your Profile	service • You are here: Home > Your RUS service
Your RUS service Your August	and a land
 This section gathers pages related to your RUS services: Your profile: displays your personal information linked to your ESA SSO and RUS accounts, Your dashboard: Ilows you to access your private dashboard, Your training: allows you to register to a training session you have been invited to participate in. 	* News from RUS One year on! Copernicus Info Session – Reykjavik – 19 September 2018 SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12 September 2018 SIWI World Water Week 2018 – Stockholm – 26-31 August 2018
	MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018 RUS Webinar - Special edition "AskRUS - Sentinel-1" - 12 July 2018 RUS Training Session - Valencia - 22 July 2018 IGARSS 2018 - Valencia - 22 27 July 2018

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

CORRUS Research and User Support	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community * 👫 Your RUS service *	
★ Your dashboard	You are here: Home > Your RUS service > Your dashboard
Request a new User Service	Chat with Support Desk
Copyright © 2017 Research and User Support	ionfact Us Terms and conditions Glossary Acconyms FAQ

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

Please help us learn more about your background by answer information will be stored in your User Profile.	ing a 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	access hubs?
© 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 (hold down CTRL key for multiple selections).	s, please 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 Guif of Trieste	
If you wish to request another tutorial exercise that doesn't appear in the	above list, please type here
its name or code. Note that you can request multiple tutorial exercises.	

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

nis is a collection of information selected fou can go back and edit this information	a across the USK forms. If necessary.	
General Information on your request:		
Years of experience in Remote Sensing	5-10 years	
Downloaded Copernicus data?	1	
Webinar codes	V HAZA02 LAND04	
Always and DI IC analysis	152102, 211204	
Thematic area	Cryosohere (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	4	
	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	×	
Region of Interest: Min Latitude	20 2202	
Max Latitude	40.5877	
Min Longitude	-463677	
MaxLongitude	-2,7205	
Reference polygons	2.7 202	
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**.

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Your dashboard								
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Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
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RUS_training1	231	2017-08-31	Open	Canoni my#equinaz	Get a webinar kit	Rate my service	Freeze my Virtual Machine(s)	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.

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6 Step by step

6.1 Data download – ESA SciHUB

In this step we will download the Sentinel-2A level 2A image from the Copernicus Open Access Hub using the online interface.

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



Go to Open HUB. If you do not have an account please sign up in the upper right corner, fill in the details and click register.

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1			Sentinel data access is free and open to all.		
			On completion of the registration form below you will receive an e-mail with a link to valida Username field accepts only alphanumeric characters plus "" "," "," and ","	ate your e-mail address. Following this you can start to download the data	
			Firstname	Listname	
			Usemame		
			Password	Continue Password	
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			Select Usage		
			Select Country		
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You will receive a confirmation email in the account you have specified: open the email and click on the link to finalize the registration.

Once your account is activated – or if you already have an account – log in.



Switch the rectangle drawing mode to pan mode by clicking on the icon in the lower left corner of the map (Green rectangle) and navigate to the Seville city area (approximate area – blue rectangle).



Switch now to drawing mode (box) and draw a search rectangle approximately as indicated below. Open the search menu by clicking to the left part of the search bar (\equiv) and specify the parameters below. Press the search button (\bigcirc) after that.

Sensing period: From 2017/06/01 to 2017/06/01 Check Mission: Sentinel-2 Product type: S2MSI2Ap

	Copernicus Open Access Hub	 Image: Image: Image:
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Pan Box Polygón Clear	comi de la Frontera	

In our case the search returns 4 results depending on the defined search area. Download scene: S2A_MSIL2A_20170601T110651_N0205_R137_T30STG_20170601T111225



Move the downloaded scenes (desktop, */home/rus/Downloads*) to the following path and unzip it by right clicking on it and using *Extract Here*.

Path: shared/Training/LAND01_CropMapping_Seville/Original

6.2 SNAP - open and explore data

In *Applications -> Processing* open SNAP Desktop; click Open product (*m*), navigate to the following path and open the product: *MTD_MSIL2A.xml* from the .SAFE folder.

Path: shared/Training/LAND01_CropMapping_Seville/Original/

The opened product will appear in *Product Explorer* window. Right click on the product and select *Open RGB Image Window* to create and visualize an RGB composition image. Check that B4, B3, and B2 are selected for the Red, Green, and Blue channels respectively. Click *OK*.



6.3 Resampling

Since the Sentinel-2 images have different pixel sizes depending on the spectral band (See 1), it is necessary to resample the product and equalize the different spatial resolutions. This step is generally required for any further processing.

Click Raster -> Geometric Operations -> Resampling





In the *I/O Parameters* tab, make sure that the source product starts with index [1]. Set the *Output folder* to the following path:

Path: shared/Training/LAND01_CropMapping_Seville/Processing/

Use this folder to save all following processing products. Go to the *Resampling Parameters* tab and select *By reference band from source product*. Select *B2* as the reference band. All other settings remain set to default values and click *Run*.

Resampling	* = *		Resam	pling		• E X
File Help		File Help				
I/O Parameters Resampling Parameters		1/O Parameters	Resampling Parameters			
Source Product Name:		Define size of re	esampled product	B2		-
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	<u>R</u> un <u>C</u> lose	L			Bur	n <u>C</u> lose

To visualize the output product, right click on it. Select Open RGB Image Window and click OK.

6.4 Subset

Since our Area of Interest (AOI) is quite small and there is no need to process the whole image we start with sub-setting the scene to a more manageable size (See \square NOTE 2). This will reduce the processing time in further steps and is recommended when the analysis is focused only over a specific area and not the complete scene. In the *Product* Explorer window, select the second resampled product and the go to *Raster -> Subset*.

NOTE 2: The subset product appears in the Product explorer but is not saved.

In the Subset menu, set the extent of the AOI to the following pixel coordinates and click OK.

Scene start x: 0 Scene start Y: 7651 Scene end X: 5689 Scene end Y: 10978

8	Specif	y Product Subset	• E
Spatial Subset	Band Subset	Metadata Subset	
		Pixel Coordinates G Scene start X: Scene start Y: Scene end X:	eo Coordinates
Mester.		Scene end Y:	10978
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		Use Pre <u>v</u> iew	Fix full <u>w</u> idth
	*	Estir	mated raw storage size: 714
		L str	OK Cancel Help

The subset product will be created inmediatly. Before continuing, save it to prevent errors. Right click on the subset product (index [3]) and select *Save Product*. Set the output folder to the following path and save it.

Path: shared/Training/LAND01_CropMapping_Seville/Processing/



To visualize the output product, right click on it. Select *Open RGB Image Window* and click OK.

6.5 Import vector data

To prepare the data for the classification, the shapefiles of the study area and training areas must be imported. Click on *Vector -> Import -> ESRI Shapefile*. Navigate to the following path, select all the shapefiles and click *Open*. Click *No* in all the *Import Geometry* dialogs.

Path: shared/Training/LAND01_CropMapping_Seville/AuxData/

Import Shapefile	Import Geometry 📣 🗉 🗙
terrs pro Landmarker To and provide the provi	The vector data set contains 6 polygonal shapes. Shall they be imported separately? If you select Yes , the polygons can be used as individual masks and they will be displayed on individual layers.
Nie gameTuceme shp" "Rice shp" "Study Area shp" "Sugar beet shp" "Surflower shp" "Tomato shp" "Water shp" "W	Attribute for mask/layer naming: Crop
hite of Syme (25K) Bhageffee (* staj) Open	ریان دسرط <u>۲</u> es <u>No</u> <u>H</u> elp

Once the vector data have been imported, do not forget to save the changes. Right click on the subset product (index [3]) and click on *Save Product*. The *Vector Data* folder of the subset product should look like the following image. Expand the product and open the *Vector Data* folder to check it.



6.6 Reproject

Before doing the classification, the product has to be reprojected due to software requirements. Click on *Raster -> Geometric Operations -> Reprojection*.



In the *I/O Parameters* tab make sure that the selected source product is the subset product (index [3]). Set Output folder to the following path:

Path: shared/Training/LAND01_CropMapping_Seville/Processing/

Move to the *Reprojection Parameters* tab. Select *Custom CRS* and choose the *UTM / WGS 84* (*Automatic*) projection. All other settings remain set to default values. Click *Run*.

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		Scene width: 5691 pixel Center longitude: 6*03'17" W
		Scene height: 3640 pixel Center latitude: 37*04'21" N
		CRS: UTM Zone 29 / World Geodetic System 1984 Show WKT
	Run Close	Run Close
	Tau Zinge	Taur Close

To visualize the output product, right click on it. Select *Open RGB Image Window* and click *OK*.

6.7 Mask

The last step before running the classification will be to mask out the pixels that are not inside the study area. To perform this process, click on *Raster -> Mask -> Land/Sea Mask*. Make sure the reprojected product (index [4]) is selected as input. Set the *Output folder* to the following path:

Path: shared/Training/LAND01_CropMapping_Seville/Processing/

Go now to the *Processing Parameters* tab. Select from *B1* to *B12* as source bands. Uncheck the option *Use SRTM 3sec*, and select *Use Vector as Mask*. Open the drop-down menu and choose *Study_Area* as mask, then click *Run*.

e	Land/Sea Mask	* = *	Ce	Land/Sea Mask	+ E ×
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To visualize the output product, right click on it. Select Open RGB Image Window and click OK.

6.8 Random Forest Classification

For this exercise, the Random Forest classification algorithm will be used (See 📒 NOTE 3).



NOTE 3: The Random Forest algorithm is a machine learning technique that can be used for classification or regression. In opposition to parametric classifiers (e.g. Maximum Likelihood), a machine learning approach does not start with a data model but instead learns the relationship between the training and the response dataset. The Random Forest classifier is an aggregated model, which means it uses the output from different models (trees) to calculate the response variable.

Decision trees are predictive models that recursively split a dataset into regions by using a set of binary rules to calculate a target value for classification or regression purposes. Given a training set with n number of samples and m number of variables, a random subset of samples n is selected with replacement (bagging approach) and used to construct a tree. At each node of the tree, a random selection of variables m is used and, out of these variables, only the one providing the best split is used to create two sub-nodes.

By combining trees, the forest is created. Each pixel of a satellite image is classified by all the trees of the forest, producing as many classifications as number of trees. Each tree votes for a class membership and then, the class with the maximum number of votes is selected as the final class.

More information about Random Forest can be found in Breiman, 2001.

Click on Raster -> Classification -> Supervised Classification -> Random Forest Classifier



To properly visualize the product later, go to *Layer -> Layer* Manager and make sure that the *Vector Data* is not selected. Now, Click on the symbol. Navigate to the following path and select the following product:

Path: /shared/Training/Crop_Mapping_Seville/Processing/

 $suset_0_of_S2A_MSIL2A_20170601T110651_N025_R137_T30STG_20170601T111225_resampled_reprojected_msk.dim$

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Move to the Random-Forest-Classifier tab and set the following parameters:

- Uncheck the Evaluate classifier option
- Set the number of trees to 500
- Select all the shapefiles as training vectors except the Study_Area
- Select all the bands (B1 to B12) as feature bands

Click now on the *Write tab*, set the *Output folder* to the following path (create the *RandomForest* folder if not created yet), and specify the output name according to the number of input images used: *RF_1_images*. Finally, click *Run*.

Path: /shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest/

Random Forest Classifier	4 T N
Productilet-Reader Random-Forest-Classifier Write	
Classdier	
(a) Train and apply classifier newClassifier	
C Load and apply classifier	Pandem Escart Classifier
🗇 Train on Raster 📧 Train on Vectors	
Evaluate classifier	ProductSet-Reader Random-Forest-Classifier Write
Evaluate Feature Power Set	Target Product
Min Power Set Size: Max Power Set Size:	
Number of training samples 5000	
Number of trees \$500	
Vettor Training	
Training vectors' Bare soil	
Conv	
Rice	Name
Sunflowe)	Name I
Study Area	INT_I Integes
Water	Save as: BEAM-DIMAP
Labels:	Directory:
Seahore Selection	/shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest
Feature bands: 01	
82	
03	
85	
26 27	
00 -	
D Help D Part	💽 Help 🕞 Run

Before visualizing the classified output, the valid pixel expression has to be changed. By default, only the pixels with a confidence threshold above 0.5 are displayed. To change this parameter, expand the Random Forest product (index [6]), open the *Bands* folder, right click on the *LabeledClasses* file, and click on *Properties*.

Delete the expression *Confidence* >= 0.5 and click *Close*.



Double click on the *LabeledClasses* file to open the classification image. You can change the colours by clicking on the *Colour Manipulation* tab located in the lower left corner or by clicking on *View -> Tool Windows -> Colour Manipulation*. Select your own colours or click on the *Import colour palette* icon (E). Navigate to the following path and select the file *Colour_Palette_SNAP.cpd*

Path: /shared/Training/LAND01_CropMapping_Seville/AuxData/Colour_Palette/



To properly visualize the new product, go to *Layer -> Layer Manager* and make sure that the *Vector data* is not selected.

7 Extra steps

7.1 Multi-temporal Random Forest classification

7.1.1 Data download

To improve the classification result obtained in the previous chapter, the number of input images can be increased. In that way, the algorithm will have more information to take into account and better output can be produced.

Go back to chapter 6.1 Data download – ESA SciHUB and follow the steps to download the Sentinel-2 images corresponding to the following dates:

2017_06_11 → S2A_MSIL2A_20170611T110621_N0205_R137_T30STG_20170611T111012

2017_06_21 → S2A_MSIL2A_20170621T110651_N0205_R137_T30STG_20170621T111222

2017_07_01 → S2A_MSIL2A_20170701T111051_N0205_R137_T30STG_20170701T111746

2017_07_11 → S2A_MSIL2A_20170711T110651_N0205_R137_T30STG_20170711T111223

2017_07_21 → S2A_MSIL2A_20170721T110621_N0205_R137_T30STG_20170721T112025

2017_07_31 → S2A_MSIL2A_20170731T110651_N0205_R137_T30STG_20170731T111220

Do not forget to move the downloaded products (desktop, */home/rus/Downloads*) to the following path and unzip them by right clicking to each one and then selecting *Extract Here*.

Path: shared/Training/LAND01_CropMapping_Seville/Original/

Go back to SNAP and close all the images. Right click on any of the products and select *Close All Products*. Click *No* when asked to save the product.

Due to software requirements, the Sentinel-2 Reader Masks have to be disabled to prevent errors. Click on *Tools -> Options* and select the *S2TBX tab*. At the *Sentinel-2 Reader Masks* tab, uncheck all the options and click *OK*.



7.1.2 SNAP Open data

Go to *File -> Open product* () and navigate to the path indicated below. In each folder, open the file *MTD_MSIL2A.xml*. Start the process with the folder on top and continue successively to open all the images in chronological order. Your *Product Explorer* window should have the same content as the one shown on the figure below.

Path: shared/Training/LAND01_CropMapping_Seville/Original/

Produ	ct Explorer × Pixel Info	
	[1] S2A_MSIL2A_20170611T110621_N0205_R137_T30STG_20170611T111012	
	[2] S2A_MSIL2A_20170601T110651_N0205_R137_T30STG_20170601T111225	
	[3] S2A_MSIL2A_20170621T110651_N0205_R137_T30STG_20170621T111222	
	[4] 52A_MSIL2A_20170701T111051_N0205_R137_T30STG_20170701T111746	
	[5] S2A_MSIL2A_20170711T110651_N0205_R137_T30STG_20170711T111223	
0-8	[6] S2A_MSIL2A_20170721T110621_N0205_R137_T30STG_20170721T112025	
	[7] SZA MSILZA 20170731T110651 N0205 R137 T30STG 20170731T111220	

7.1.3 Batch Processing

Before running the multi-temporal Random Forest Classification, the images must be pre-processed as before. However, since we have more inputs to analyze, we will use the Batch Processing option included in SNAP. This feature allows the execute graphs including processing tools to a set of inputs.

Click on *Tools -> Batch Processing* or click on the Batch Processing icon (¹⁹⁹⁷).

Ele Edit Yew Analysis Layer Vector Raster Optical Radar	Isola Window Help Metadata +		0.
		and the second second	TANA AND INCOME
Product Explorer X Prod Info → [1] ISA, MSLA, 2017/0017111051, M0205, 9L37, T10575, 201 → [2] ISA, MSLA, 2017/0017110651, M0205, 9L37, T10575, 201 → [3] ISA, MSLA, 2017/0017110651, M0205, 9L37, T10575, 201 → [4] ISA, MSLA, 2017/0171110611, M0205, M37, T10575, 201 → [4] ISA, MSLA, 2017/01711710611, M0205, M37, T10575, 201 → [5] ISA, MSLA, 2017/017117110611, M0205, M37, T10575, 201 → [6] ISA, MSLA, 2017/017117110611, M0205, M137, T10575, 201 → [6] ISA, MSLA, 2017/017117110611, M0205, M137, T10575, 203	Itach Yorad Gaung Yama Conten Treat Catholog St Consect Status R ADI Mancoma External Tools > Manage External Tools Plagma Digitions	PANEA Proceeding	
Newligation: X [Colour Manpulation - World View	-	Target Folder Save as (BEAH-OMAR) Directory Johand TheomopLANDEL CreptApping, Swille/Processing/ Skip expelling target files (2) Keep source product name	8 Products
		Lead Graph Run	Class Heb

Click on the Add Opened icon (\blacksquare) to load all the images in the Batch Processing. Press the refresh button (\bowtie) to update the metadata information, and uncheck the Keep source product name option.

Once the Sentinel-2 images are loaded, the graph containing the pre-processing tools have to be inlcuded as well. Click on *Load Graph*, navigate to the following path and select the file *Pre_Processing.xml*.

Path: shared/Training/LAND01_CropMapping_Seville/AuxData/Batch_Processing_Graph/

yu rarameters Resam	iple Subset	Import-Vector	Reproject	Land-Sea-Mask	Write
File Name	Туре	Acquisition	Track	Orbit	4
S2A_MSIL2A_20170701T	S2_MSI_Level	01jul2017	99999	99999	
52A_MSIL2A_20170621T	S2_MSI_Level	21jun2017	99999	99999	
52A_MSIL2A_20170601T	S2_MSI_Level	01jun2017	99999	99999	-
S2A_MSIL2A_20170611T	S2_MSI_Level	11Jun2017	99999	99999	-
S2A_MSIL2A_20170721T	S2_MSI_Level	21Jul2017	99999	99999	
S2A_MSIL2A_20170711T	S2_MSI_Level	11Jul2017	99999	99999	
S2A_MSIL2A_20170731T	S2_MSI_Level	31Jul2017	99999	99999	
Tarnat Folder					7 Produ
Target Folder					7 Produ
Target Folder Save as:	+				7 Produ
Target Folder Save as:	+				7 Produ
Target Folder Save as: Economic Directory:	······································				7 Produ

Go to the *Resample* tab and choose the option *By reference band from source product*. Open the drop-down menu and choose *B2* as reference band. All other settings remain set to default values.

I/O Parameters Resample Subset Imp	ort-Vector Reproject Land-Sea-Mask Write				
Define size of resampled product	(B2)				
By reference band from source product:	Resulting target width: 10980				
	Resulting target height: 10980				
	Target width 20,960				
By target width and height:	Target height				
	Width / height ratio: 1.00000				
	100				
By pixel resolution (in m):	Resulting target width: 1058				
	Resulting target height 1098				
Upsampling method	Nearest				
Downsampling method	First				
Flag downsampling method	First				
Resample on pyramid levels (for faster ima	ging)				

Click on the *Subset* tab and set all the bands from B1 to B12 as source bands. Select *pixel coordinates* and specify the following values. All other settings remain set to default values.

X: 0 Y: 7651 Width: 5689 Height: 3327

100 D	Vana	Constant.		V Providence	Vicel		Value 1
I/O Parameters	Resample	Subset	Import-vector	Reprojec	Land-	Sea-Mask	write
Source Bands:	B1						
	B2						1
	B3						
	84						
	BG						
	B7						
	B8						
Copy Metadata	a						
Rivel Coordina	tes O Gener	anhic Cool	rdinatas				
e rixer coordina	tes Googi	aprile cool	Tuniacea		-		
¢;	0		Y:		7651	-	
	5689		height:		3327	7	
Width:			Sub-samp	ng Y:	1		
Vidth: Sub-sampling X:	1						
Width: Sub-sampling X:	1						
Vidth: Sub-sampling X:	1						
Vidth: Sub-sampling X:	1						
Width: Sub-sampling X:	1						
Width: Sub-sampling X:	1						
vidth: Sub-sampling X:	1						
Width: Sub-sampling X:	1						
Width: Sub-sampling X:	1						
Width: Sub-sampling X:	1						

Click on the *Import-Vector* tab. Navigate to the following path and select the *Study_Area.shp* file.

Path: *shared/Training/LAND01_CropMapping_Seville/AuxData/*

	Batch Proces	sing : Pre_Process	sing.xml	* • ×
File Graphs				
I/O Parameters	Resample Subse	t Import-Vector	Reproject Land-S	ea-Mask Write
Vector File: <u>/home</u> ₽ Separate Shap	/rus/shared/Training/I	AND01_CropMapping	g_Seville/AuxData/St	idy_Area.shp
		Load	Graph Run	<u>C</u> lose <u>H</u> elp

Click on the *Reproject* tab and select the *Custom CRS* option. At the *Projection, open the drop-down* menu and select the option *UTM / WGS 84 (Automatic)*. All other settings remain as default.

O Parameters Resample	Subset Import-Vecto	Reproject	Land-Sea-Mack	Write
	(cno)	in the project	Land Sca Hask	Mile
oordinate Reference System	ICRSI			
Custom CRS				
Geodetic datum:	and the second s			*
Projection: UTM / W	GS 84 (Automatic)			-
			Projection Paramet	arc
		-	e caje e dan e ar briter	
Predefined CRS			St	elect
Output Settings				
Preserve resolution	Reproject tie-poir	nt grids		
Output Parameters	No-data value:	NaN		
Supplier arbitraters	1			
Add delta latilon bands	Resampling method:	Nearest		-
Output Information				
Scene width: 5690 pixel	Cent	er longitude:	6*03'16" W	
Scene height 3556 pixel	Cent	er latitude:	37"04'07" N	
			ſ	

Click on the Land-Sea-Mask. Select from *B1* to *B12* as source bands. Uncheck the option *Use SRTM 3sec* and select *Use Vector as Mask.* At the drop-down menu choose *Study_Area_1* as mask. All other settings remain set to default values.

В	atch Processing : Pre_Processing.xml	* 🗆 X
File Graphs		
I/O Parameters Resar	mple Subset Import-Vector Reproject Land-Sea-Mask	Write
Source Bands:	B1 B2 B3 B4 B5 B6 B7 B8	
O Mask out the Land		
🔾 Mask out the Sea		
Use SRTM 3sec		
Use Vector as Mask		
	Study_Area_1	*
	Invert Vector	
Extend shoreline by (pixel	s]: 0	
	Load Graph Run <u>C</u> lose	Help

Finally, click on the *Write* tab and set the output directory to the following path. Then, click *Run*. If not created yet, add the *Batch_Processing folder* within *the Processing* directory.

Path: shared/Training/LAND01_CropMapping_Seville/Processing/Batch_Processing/

Name: ected_Subset_S2A_MSIL2A_20170611T110621_N0205_R137_T30STG_20170611T111012_resampled Save as: BEAM-DIMAP	VO Parameters	Pesample	Subset	Import-Vector	Reproject	Land-Sea-Mask	Write
Directory:	Target Product Name: ected_Subset_S2 Save as: BEAM-D	2A_MSIL2A_20: DIMAP	170611711	0621_N0205_R13	7_T30STG_20	170611T111012_r	esampled
/snared/fraining/LANDUL CropMapping Seville/Processing/Datch Procesing/	Directory:	ning/LAND01 C	ropMappin	g Seville/Process	sing/Batch Pr	ocesing/	

7.1.4 Random Forest Classification

After pre-processing the images, the random forest classification can be applied. First, select all the Sentinel-2 original images (files in the *Product Explorer* window with index [1] to [7]), right click and select *Close All Products*. Click *No* when asked to save the product.

Select now the first product (index [8], date 2017_06_01) and click on *Vector -> Import -> ESRI Shapefile*. Navigate to the following path, select all the shapefiles except the *Study_Area.shp* shapefile and click *Open*. Click No in all the *Import Geometry* dialog that will appear.

Path: shared/Training/LAND01_CropMapping_Seville/AuxData/

Once the vector data has been imported, do not forget to save the changes. Right click on the product (index [1]) and click on *Save Product*. The *Vector Data* folder of the subset product should look like the following image. Expand the product and open the *Vector Data* folder to check it.



Click on Raster -> Classification -> Supervised Classification -> Random Forest Classifier

On the Product-Reader tab, click on the *Add Opened* icon ($\overline{\square}$) to load all the images. Press the refresh button ($\overline{\square}$) to update the metadata information.

You can now decide the number of images you want to use for the multi-temporal Random Forest Classification. The classification can be repeated as many times as desired and with different number of Sentinel-2 images as input. To remove an image from the list, select it and press the — icon.

Remember to always include the image from 2017_06_01 (index [1]) since it is the one containing the training vectors.

	Random Forest Classifier						
ProductSet-Reader	Rano	dom-Forest-Class	ifier Write				
File Name		Type	Acquisition	Track	Orbit		
rojected_Subset_S2/	A. M	S2 MSI Level	11Jun2017	99999	99999	T T	
rojected Subset S24	A_M	S2_MSI_Level	01Jun2017	99999	99999		
rojected_Subset_S2/	A_M	S2_MSI_Level	21Jun2017	99999	99999	4	
rojected_Subset_52/	A_M	S2_MSI_Level	01Jul2017	99999	99999		
rojected_Subset_S2/	A_M	S2_MSI_Level	11Jul2017	999999	99999	-	
rojected_Subset_S2/	A_M	S2_MSI_Level	21Jul2017	99999	99999		
rojected_Subset_S24	A_M	S2_MSI_Level	31Jul2017	99999	99999	-	
						-	

For this exercise we will run the multi-temporal Random Forest Classification using all the S2 images.

Move to the Random-Forest-Classifier tab and set the following parameters:

- Select the option Train and apply classifier
- Uncheck the Evaluate classifier option
- Set the number of trees to 500
- Select all the shapefiles as training vectors except the Study_Area.shp
- Select all the bands as feature bands

Click now on the *Write* tab, set the output folder to the following path, and specify the output name according to the number of input images (e.g. ' RF_7 _images'). Finally, click *Run* (See 1 NOTE 4).

	Random Forest Classifier	* • *	
ProductSet-Reade	r Random-Forest-Classifier Write		
Classifier			
Train and app	ly classifier new Classifier		
C Load and appl	y classifier	8	
	C Train on Raster . Train on Vectors		Random Forest Classifier
Evaluate classifier			
Evaluate Feature	Power Set		ProductSet-Reader Random-Forest-Classifier Write
	Min Power Set Size Max Power Set Size		Target Product-
Number of trainin	g samples (5000		
Number of trees	500		
Varter Training			
Training vectors:	Study Area 1: projected Subset S2A MSH2A 20170611T110621 N0205. Bare soll projected Subset S2A MSH2A 20170611T110621 N0205 R1	*	
	Built up: projected_Subset_S2A_MSIL2A_201706117110621_N0205_R13		
	Corn projected Subset S2A MSIL2A 201706117110621 N0205 R137 T.		Name:
	Lucerne projected Subset 52A MSIL2A 201706117110621 N0205 R13/		RF_7_Images
	Rice:projected_Subset_S2A_MSIL2A_20170611T110621_N0205_R137_T3		Save as BEAM-DIMAP
	Sugar beet projected Subset S2A MSIL2A 20170611T110621 N0205 R.	*	Directory
Feature Selection			/shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest
Feature bands:	B1:projected Subset S2A MSIL2A 20170611T110621 N0205 R137 T30		
	B2. projected_Subset_S2A_MSiL2A_20170611T110621_N0205_R137_T30	E	
	B3 projected_Subset_S2A_MSH_2A_20170611T110621_N0205_R137_T30		
	B5 projected Subset 52A MSIL2A 20170611110621 N0205 R137 T30		
	B6 projected Subset S2A MSIL2A 20170611T110621 N0205 R137 T30		
	87: projected_Subset_52A_MSIL2A_20170611T110621_N0205_R137_T30		
	Ba projected_bubset_b2A_MbR2A_20170611T110621_N0205_R137_T30	-	
	Quelo Dous		Ditteln Nam
	Witten D Kun		Contraine Contraine

Path: shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest/

To properly visulize the result, go to *Layer -> Layer Manager* and make sure that the *Vector Data* field is not selected. Once the classificatin is done, remember to change the confidence threshold. Expand the Random Forest classification product, open the *Bands* folder right click on the *LabeledClasses* file, and click on *Properties*. Delete the valid-pixel expression *Confidence >= 0.5* and click *Close*.

Double click on the *LabeledClasses* file to open the classification image. You can change the colours by clicking on the *Colour Manipulation* tab located in the lower left corner or by clicking on *View -> Tool Windows -> Colour manipulation*. Select your own colours or click on the 'Import colour palette'

icon (
). Navigate to the following path and select the file Colour_Palette_SNAP.cpd

Path: *shared/Training/LAND01_CropMapping_Seville/AuxData/Colour_Palette/*

NOTE 4: Due to a SNAP issue, it is possible that an error will appear. In case you see the message Error: [Nodeld: Random-Forest-Classifier] Cannot select feature band B1 in more than one product you need to rename all the bands of 6 out of 7 products (do not change the first one, the image from 20170601, since it contains the training vectors). For this, expand each product, open the Bands folder, right click on each band, and click Properties. As an example, change the name of the first band in the second product (20170611) from B1 (443 nm) to 1a as shown in the image below. Do the same for the remaining bands.

For the third product change the name from B1 (443 nm) to 1b an continue accordingly. Repeat this step for all bands of the remaining products. Remember to save the products after the changes have been made (right click on the product -> *Save Product.*

o 🗃 Bands	🕈 🗃 Bands
📕 B1 (443 nm)	🔶 🔲 la
B2 (490 nm)	2a
B3 (560 nm)	- 🚺 3a
B4 (665 nm)	- 🔲 4a
B5 (705 nm)	🔲 5a
B6 (740 nm)	🔲 6a
B7 (783 nm)	🔲 7a
B8 (842 nm)	- 6a
B8A (865 nm)	- Sla
B9 (945 nm)	9a
- 🔲 B11 (1610 nm)	🔲 11a
- 🔲 B12 (2190 nm)	12a

7.2 Export to QGIS

To import the classification raster in QGIS, we will convert it into GeoTIFF format. You can perform this step for the single-date Random Forest classification or for the multi-temporal Random Forest classification.

Expand now the classified product and open the LabeledClasses band.

Click on *File -> Export -> GeoTIFF* and save the product in the following path with the appropriate name: RF_ + number of images used + _images (e.g. *RF_7_images*).

Path: shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest/



Minimize SNAP and open QGIS (Applications -> Processing -> QGIS Desktop). Press the *Add Raster Layer* button (K). Navigate to the following path and select the Random Forest classification GeoTIFF file. Click Open.

Path: shared/Training/LAND01_CropMapping_Seville/Processing/RandomForest/

The classification product is open as a multiband raster file. To change the visualization, right click on opened file and select *Properties*.



Select the *Style* tab on the left panel and choose the following parameters:

Render type: Singleband pseudocolor

Mode: Equal Interval

Classes: 12

Min / Max: -1 / 10

Press *Classify*. You can choose your own colours or use a predefined colour palette. Press the 'Load Colour Map' icon (), navigate to the following path, select *Colour_Palette_QGIS.txt* and click *OK*. Path: *shared/Training/LAND01_CropMapping_Seville/AuxData/Colour_Palette/*

4	Layer Properties -	F_7_images Style 👘 🖉 🐇
General	# Band rendering	
😻 Style	Render type Singleband pse	docolor 👻
Transparency	Band Band 1 (ray) 🛨 Generate new color map
🚔 Pyramids	Color interpolation Linear	Edit F Invert
📉 Histogram	۵ 🗖 🖉 🖉 🖻 🕮	Mode Equal interval \star Classes 12 🛨
() Metadata	Value Color Label	Min -1 Max 10
	-1.000000 -1 0.000000 0	Classify
	1.000000 1 2.000000 2 3.000000 3 4.000000 4	Min / max origin: User defined
	5.000000 6.000000 7.000000 7	Cumulative 2.0 + - 98.0 + %
	8,000000 8 9,000000 9	
		C Mean +/- standard deviation x 2.00 ±
		Extent
		🕫 Full 📭 Estimate (faster)
		C Current C Actual (slower)
		Load
	Style •	OK Cancel Apply Help



THANK YOU FOR FOLLOWING THE EXERCISE!

8 Further reading and resources

Breiman, L. (2001). Random Forests. *Machine Learning*, 45, 5–32, 45(1), 5–32.

Mentch, L., & Hooker, G. (2016). Quantifying Uncertainty in Random Forests via Confidence Intervals and Hypothesis Tests. Journal of Machine Learning Research, 17(1), 1–41. http://doi.org/10.1080/10618600.2016.1256817

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