TRAINING KIT – R02

CROP MAPPING WITH SENTINEL-2 FOCUSING ON ALGORITHMS
Case Study: Seville 2017, Spain

Research and User Support for Sentinel Core Products

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

Authors would be glad to receive your feedback or suggestions and to know how this material was used. Please, contact us on training@rus-copernicus.eu

Cover images produced by RUS Copernicus

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Date of publication: July 2021

Version: 1.1

Suggested citation:

Serco Italia SPA (2020). *Crop mapping with Sentinel-2 focusing on algorithms (version 1.1).* Retrieved from RUS Lectures at https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/

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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 run a supervised and unsupervised pixel-based classification using the Random Forest, Support Vector Machine and K-means algorithms and Sentinel-2 as input data over an agricultural area in Seville, Spain.

2   Crop mapping – background

Agricultural area near Seville (Spain) seen by Sentinel-2. Source: RUS Copernicus

Reliable information on agriculture and crops is required to assist and help in the decision-making process of different applications. Different methods can be used to gather this information, but satellite earth observation offers a suitable approach based on the coverage and type of data that are provided.

A few years ago, the European Union (EU) started an ambitious program, Copernicus, which includes the launch of a new family of earth observation satellites known as the Sentinels.

Amongst other applications, this new generation of remote sensing satellites will improve the observation, identification, mapping, assessment, and monitoring of crop dynamics at a range of spatial and temporal resolutions.

3   Training

Approximate duration of this training session is two hours.

3.1   Data used

*   7 Sentinel-2A images acquired from June 1st until July 31st 2017 [downloadable at https://scihub.copernicus.eu/ using the .meta4 file provided in the AuxData folder of this exercise]

*   Pre-processed data stored locally
    @/shared/Training/R02_CropMapping_R/AuxData/
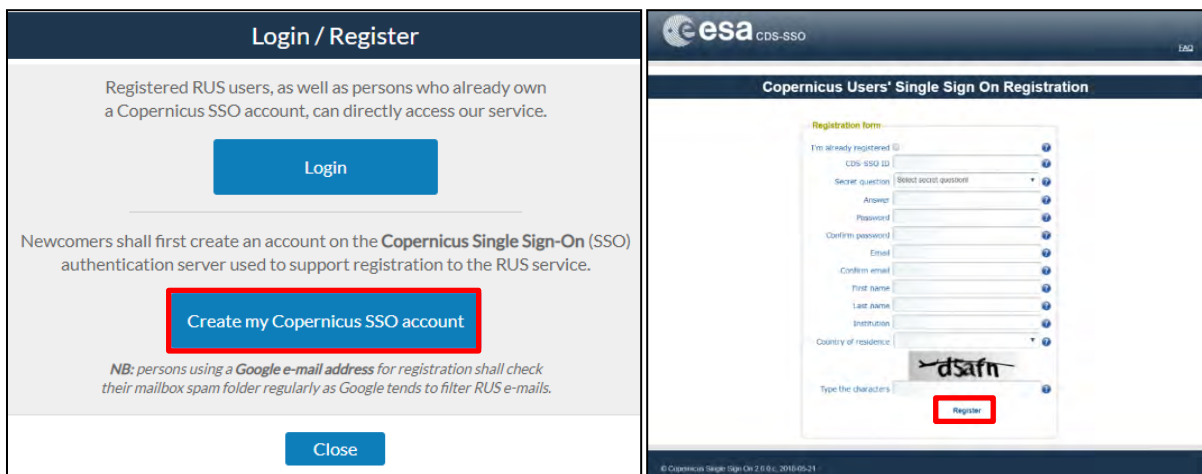
3.2   Software in RUS environment

Internet browser, R + Jupyter Notebook

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 (www.rus-copernicus.eu) and click on *Login/Register* in the upper right corner.
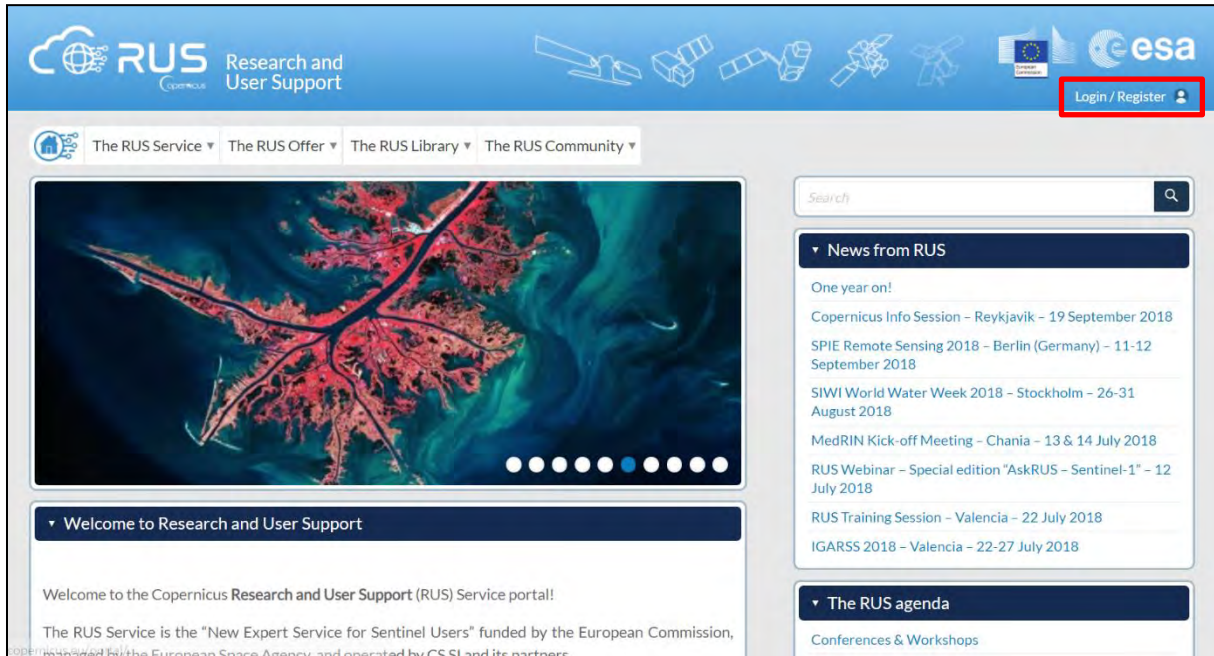
Select the option *Create my Copernicus SSO account* and then fill in ALL the fields on the **Copernicus Users' Single Sign On Registration**. Click *Register*.

Within a few minutes you will receive an e-mail with activation link. Follow the instructions in the e-mail to activate your account.

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

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

5   Step by step

5.1   Data download – ESA SciHUB

Before starting the exercise, we need to make sure that we are registered in the Copernicus Open Access Hub so that we can access the free data provided by the Sentinel satellites.

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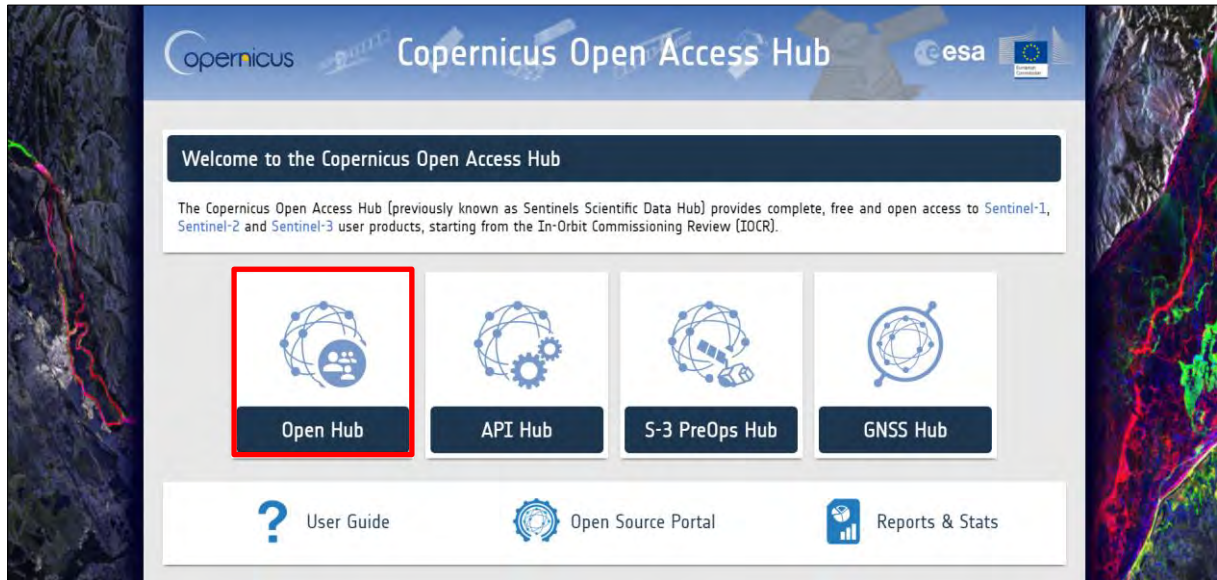
Go to Open HUB. If you do not have an account please sign up in the upper right corner, fill in the details and click register.

You will receive a confirmation email on the e-mail address 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.

5.2   Download data

In this exercise, we will use 7 Sentinel-2 images (See 📋 NOTE 1) during the year 2017. The following table shows the date and reference of the images that will be used:

📋 NOTE 1: Due to the ESA policy on the availability of Sentinel data on the Copernicus Open Access Hub and to ensure the continued access to all Sentinel data at all time, the Long-Term Archive (LTA) Access has been implemented to roll-out the oldest data from the online access. More information about the LTA can be found in the following links:

https://scihub.copernicus.eu/userguide/#LTA_Long_Term_Archive_Access
https://scihub.copernicus.eu/userguide/LongTermArchive.
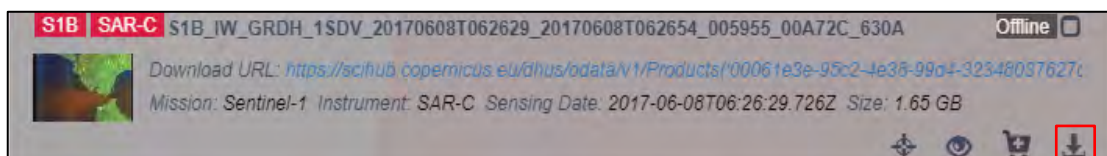
To download a product from the LTA, click on the *Download Product* icon - 📥. A confirmation message will appear informing you that your request has been queued and the product added to your Cart.
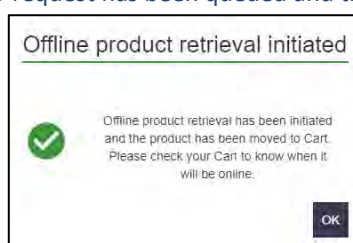
You will have to manually check your Cart from time to time to know when the product is available to be downloaded (no automatic notification will be sent). Once online, the product will remain available for 4 days until been roll-out to the LTA again.

Please note that every user account is only allowed to request 1 offline product every 30 minutes, if there is free space in the queue. The number of concurrent requests for offline products from all users is limited. You may receive an error when trying to download. If so, try again later.

SATELLITE	DATE	IMAGE ID
Sentinel-2	2017-06-01	S2A_MSIL2A_20170601T110651_N0205_R137_T30STG_20170601T111225
	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

To improve the data acquisition process, we will use a download manager (See 📋 NOTE 2) to take care of downloading all products that will be used in this exercise. The metadata of the Sentinel products are contained in a *products.meta4* file created using the 'Cart' option of the Copernicus Open Access Hub.
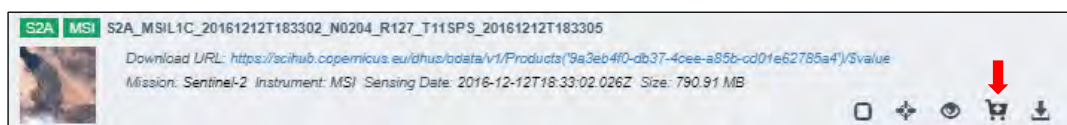
> 📝 NOTE 2: A download manager is a computer program dedicated to the task of downloading possibly unrelated stand-alone files from (and sometimes to) the Internet for storage. For this exercise, we will use aria2. Aria2 is a lightweight multi-protocol & multi-source command-line download utility. More info at: https://aria2.github.io/

Before using the downloading manager and the .meta4 file, let us test if *aria2* is properly installed in the Virtual Machine. To do this, open the Command Line (in the bottom of your desktop window) and type:

```
aria2c
```

> 📝 NOTE 3: The Copernicus Open Access Hub allows you to add products to a 'Cart'. For that, perform a query; select the desired products from the result list and click on the 'Add Product to Cart' icon - 🛒
>
>
>
>
>
> To view the products present in the cart just click anytime on the User Profile icon on top right corner of the screen and then on "Cart". To download the products contained in the cart just click on "Download Cart" on the bottom right of the page. A download window will pop up, asking the user confirmation to save a .meta4 file named *'products.meta4'*. This file contains all the metalinks of the products.

If *aria2* is properly installed, the response should be as follows.

If the response is '-*bash aria2c: command not found'* it means *aria2* is not installed (See 📝 NOTE 4).

Once *aria2* is ready to use, we can start the download process. For that, we need to navigate to the folder where the *products.meta4* is stored. Type the following command in the terminal and run it.

```
cd /shared/Training/R02_CropMapping_R/Original/
```
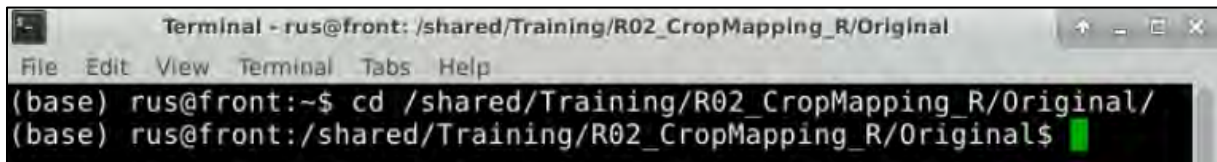

Next, type the following command (in a single line) to run the download tool. Replace *username* and *password* (leave the quotation marks) with your login credentials for Copernicus Open Access Hub (COAH). Do not clear your cart in the COAH until the download process is finished.

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

The Sentinel products will be saved in the same path where the *products.meta4* is stored. Move the Sentinel-2 images to its corresponding folder and do not forget to unzip the Sentinel-2 products after that (once unzip, you can delete the zip products to save storage capacity). Your folders should have the same structure as shown below.

Sentinel-2 folder → */shared/Training/R02_CropMapping_R/Original/*
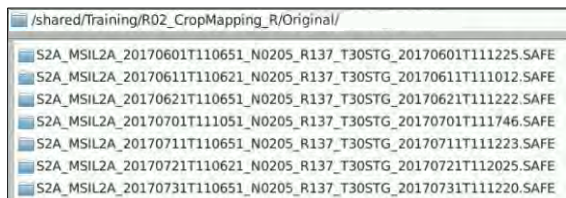
5.3 R – Processing

At this point, we are ready to start the next part of our analysis. This exercise will be done using R (See ⬜ NOTE 10) code implemented in a Jupyter Notebook (See ⬜ NOTE 11).

We will open Jupyter Notebook by launching it from a specific Conda environment (see ⬜ NOTE 12). For that, open Terminal in your RUS Virtual Machine and copy-paste the following script. Then, press enter to run it:

> ⬜ NOTE 10: R is a language and environment for statistical computing and graphics. It provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering…) and graphical techniques, and is highly extensible. R can be extended (easily) via *packages*. There are about eight packages supplied with the R distribution and many more are available through the CRAN family of Internet sites covering a very wide range of modern statistics. It is available as Free Software under the terms of the Free Software Foundation's GNU General Public License in source code form.

> ⬜ NOTE 11: Project Jupyter is a non-profit, open-source project, born out of the IPython Project in 2014 as it evolved to support interactive data science and scientific computing across all programming languages. Notebook documents (or "notebooks", all lower case) are documents produced by the Jupyter Notebook App, which contain both computer code and rich text elements (paragraph, equations, figures, links, etc…). Notebook documents are both human-readable documents containing the analysis description and the results (figures, tables, etc..) as well as executable documents which can be run to perform data analysis. More info at: www.jupyter.org

> ⬜ NOTE 12: Anaconda is a free and open-source distribution of the Python and R programming languages for scientific computing (data science, machine learning applications, large-scale data processing, predictive analytics, etc.), that aims to simplify package management and deployment. Package versions are managed by the package management system *conda*. More info at: https://www.anaconda.com/distribution/
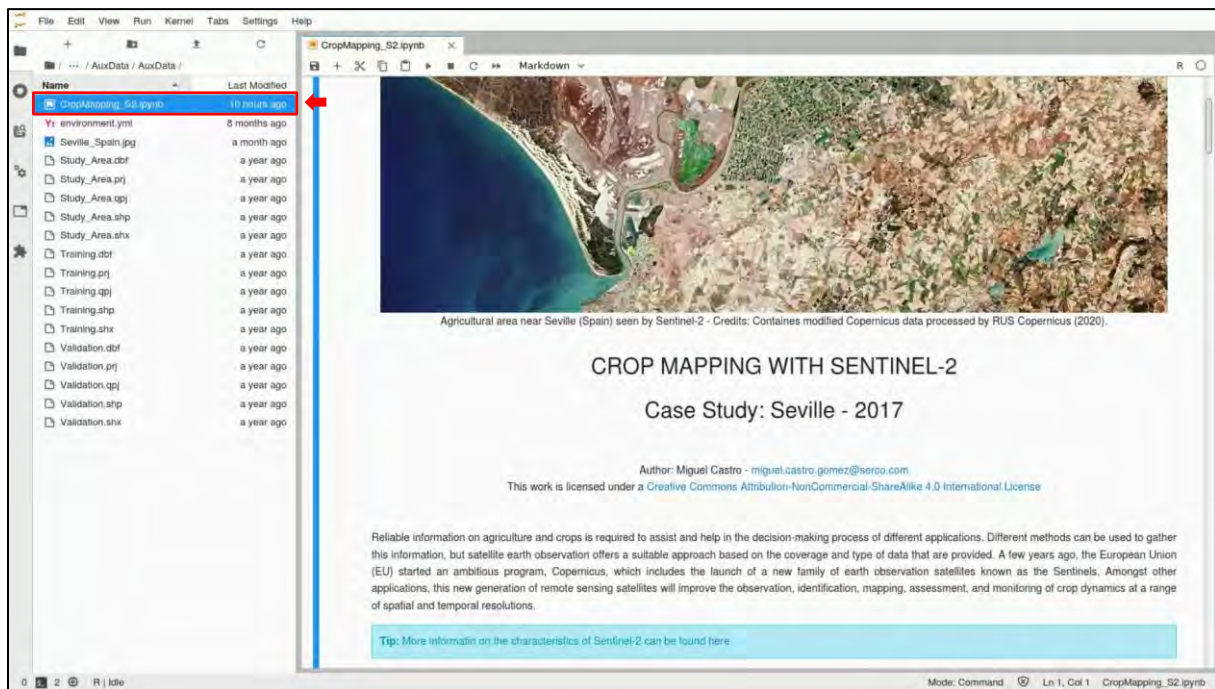
```
conda activate env_r01
```

Next, write Jupyter Notebook and press enter to launch the application. Once open, navigate to the following path inside the Jupyter Notebook GUI and open the file *CropMapping_S2.ipynb*

```
jupyter lab
```
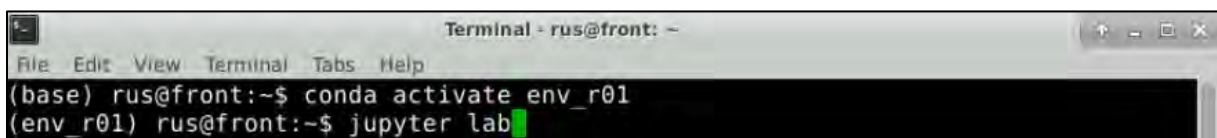

Path → */shared/Training/R02_CropMapping_R/AuxData/*

Read the Notebook and follow the instructions to run the R code and complete the exercise.

THANK YOU FOR FOLLOWING THE EXERCISE!

6 Further reading and resources

An Introduction to R

R Cheat Sheets

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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