

**TRAINING KIT – R01**

## **SENTINEL-2 DATA PROCESSING USING R**

### **Case Study: Imperial Valley, USA**



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](mailto:training@rus-copernicus.eu)

Cover image credits: ESA

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

Date of publication: November 2020

Version: 1.1

Suggested citation:

Serco Italia SPA (2020). *Sentinel-2 data processing using R (version 1.1)*. Retrieved from RUS Lectures at <https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/>



This work is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

---

#### DISCLAIMER

While every effort has been made to ensure the accuracy of the information contained in this publication, RUS Copernicus does not warrant its accuracy or will, regardless of its or their negligence, assume liability for any foreseeable or unforeseeable use made of this publication. Consequently, such use is at the recipient's own risk on the basis that any use by the recipient constitutes agreement to the terms of this disclaimer. The information contained in this publication does not purport to constitute professional advice.

## Table of Contents

1	Introduction to RUS.....	4
2	Sentinel-2 – background.....	4
3	Training.....	4
3.1	Data used.....	4
3.2	Software in RUS environment .....	4
4	Register to RUS Copernicus .....	5
5	Step by step .....	7
5.1	Data download – ESA SciHUB .....	7
5.2	Anaconda environment installation .....	10
5.3	Sentinel-2 Processing using R - JupyterLab .....	10
6	Further reading and resources .....	12



## 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 learn how to process Sentinel-2 data using the R programming language.

## 2 Sentinel-2 – background



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 Sentinels. The Copernicus Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other. It aims at monitoring variability in land

surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes. The coverage limits are from between latitudes 56° south and 84° north.

In this exercise you will learn how to use the R programming language to process Sentinel-2 data. The R code can be found in the Jupyter Notebook delivered with this training kit. Although highly recommended, the exercise DOES NOT require any R programming skills and can be followed by any participant. You will not be asked to write any code but to follow the methodology and understand the processing steps.

## 3 Training

Approximate duration of this training session is **one** hour.

**The Training Code for this tutorial is R01. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the RUS portal and open a User Service request from Your RUS service > Your dashboard.**

### 3.1 Data used

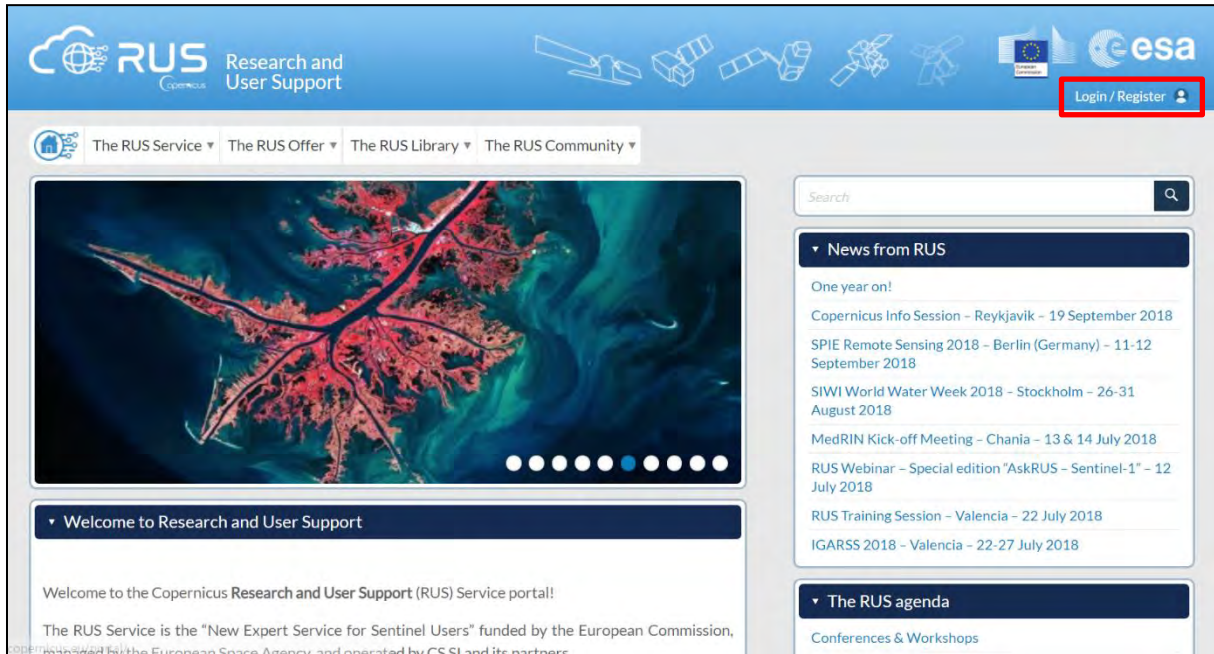
- 6 Sentinel-2 images acquired during 2020
- Pre-processed data stored locally  
`@/shared/Training/R01_Sentinel2Processing_R/AuxData/`

### 3.2 Software in RUS environment

Internet browser, JupyterLab, R, Anaconda

## 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](http://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.

### Login / Register

The registration system to access the RUS service platform has moved toward the COPERNICUS Single Sign On authentication server.

- New Users who have not yet registered to the RUS portal shall first create a COPERNICUS SSO account.

Note that your Copernicus SSO account will be activated only after the reception of the third email sent by the Copernicus service. We advise you to consult [this document](#) and [this page](#) to facilitate your registration procedure.

**REGISTER COPERNICUS SSO account**

Users who already have a COPERNICUS SSO account can login here:

**Login**

**Close**

### Credentials

CDS-SSO ID

Password

Max Idle Time

Max Session Time

**Login** **Reset**

[Forgot your password?](#)

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

### Do you want to subscribe for a new RUS account?

Your ESA-SSO subscription data:

Login

First Name

Last Name

Email

Organization

Country

**Additional subscription information**

Please complete the following information:

Where did you hear about the RUS service?  
Select one or more items

☐ outreach event  
☐ colleagues  
☐ newsletter  
☐ conference  
☐ social media  
☐ other

Institution type

Phone number

Title

**Subscribe** **Cancel**

### RUS Research and User Support

The RUS Service

**Your RUS service:**

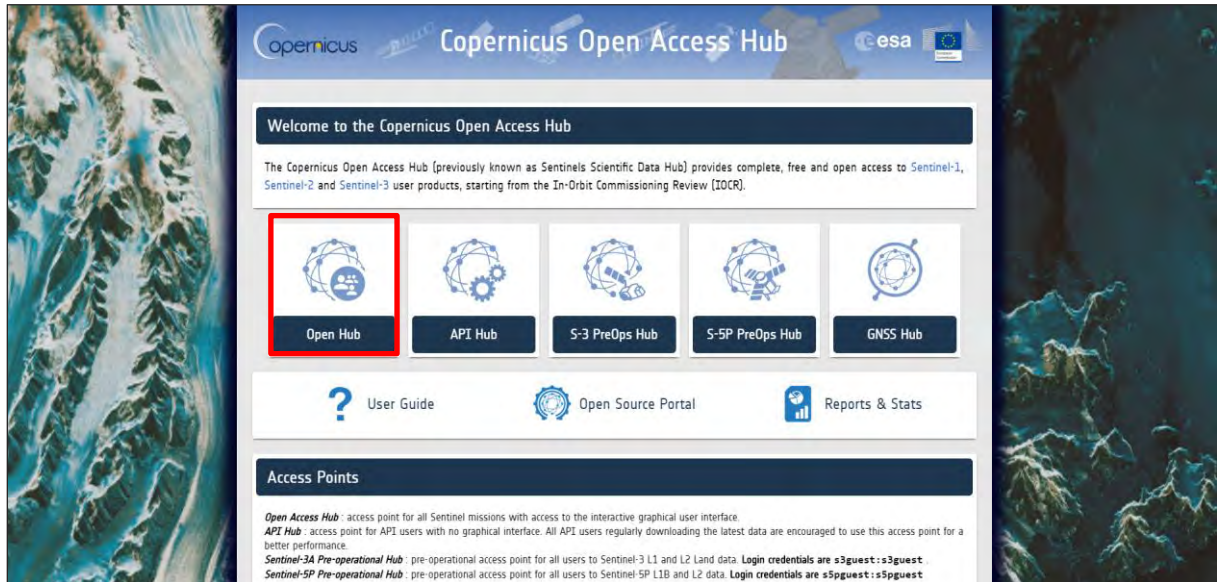
- This section gathers pages related to you
- Your profile:** displays your personal data
- Your dashboard:** allows you to follow your progress
- Your training:** allows you to register for new courses

## 5 Step by step

### 5.1 Data download – ESA SciHUB

Before starting the exercise, make sure you are registered in the Copernicus Open Access Hub so that you 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, sign up in the upper right corner, fill in the details and click register.

The image shows the 'Register new account' form on the Copernicus Open Access Hub. The form is titled 'Register new account' and includes a sub-header 'Sentinel data access is free and open to all.' Below this, there's a paragraph explaining the registration process. The form fields are: Firstname, Lastname, Username, Password, Confirm Password, E-mail, Confirm E-mail, Select Domain (dropdown), Select Usage (dropdown), and Select Country (dropdown). At the bottom right, there's a 'REGISTER' button, which is highlighted with a red arrow. A red arrow also points to the 'REGISTER' button in the top right corner of the page.


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.



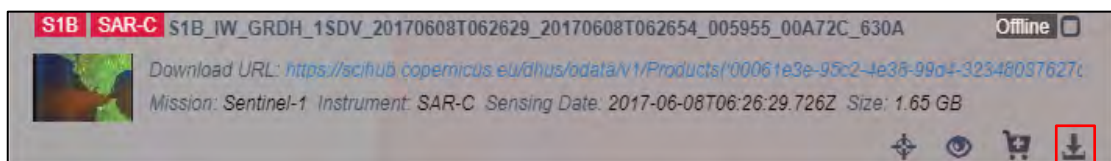



In this guide, we describe the procedure to download the Sentinel-2 images (See  NOTE 1).

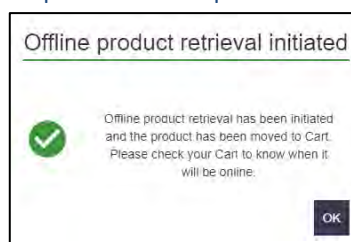
 NOTE 1: Due to the ESA policy on the availability of Sentinel data on the Copernicus Open Access Hub and to ensure the continued access to all Sentinel data at all time, the Long-Term Archive (LTA) Access has been implemented to roll-out the oldest data from the online access. More information about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

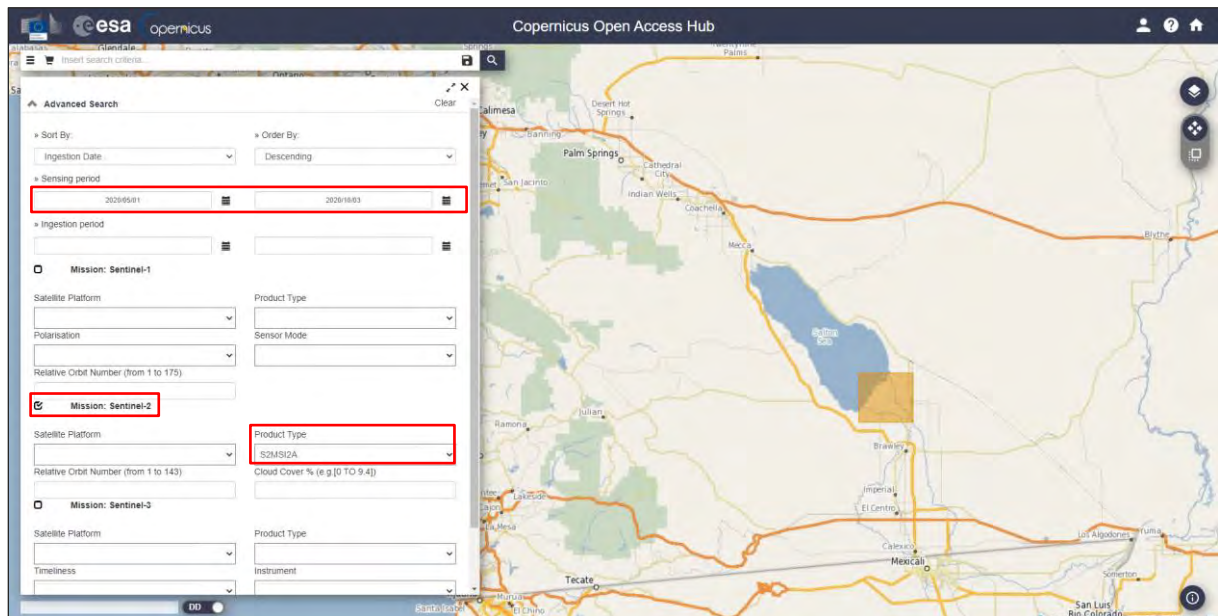
Make sure you repeat the same procedure and download the product for 2020. Define the study area over the Imperial Valley (California, USA). Then, open the search menu by clicking to the left part of the search bar () and specify the parameters below. Press the search button () after that.



**Sensing period:** 2020/05/01 – 2020/10/03

**Check Mission:** Sentinel-2

**Product type:** Level 2A






Download the products listed below (they will be saved in `/home/rus/Downloads`) and move it to the following path. You can also copy-paste the image ID in the search bar of the Copernicus Open Access Hub to find the products.


Path: `/shared/Training/R01_Sentinel2Processing_R/Original/`

SATELLITE	DATE	IMAGE ID
Sentinel-2	2020-05-05	S2A_MSIL2A_20200505T181921_N0214_R127_T11SPS_20200505T222608.SAFE
	2020-06-04	S2A_MSIL2A_20200604T181931_N0214_R127_T11SPS_20200604T221557.SAFE
	2020-07-04	S2A_MSIL2A_20200704T181931_N0214_R127_T11SPS_20200704T221517.SAFE
	2020-08-03	S2A_MSIL2A_20200803T181931_N0214_R127_T11SPS_20200803T224210.SAFE
	2020-09-02	S2A_MSIL2A_20200902T181931_N0214_R127_T11SPS_20200902T224557.SAFE
	2020-10-02	S2A_MSIL2A_20201002T182211_N0214_R127_T11SPS_20201002T220706.SAFE

## 5.2 Anaconda environment installation

In this exercise we will use R code in JupyterLab to process the Sentinel-2 product we have previously downloaded. However, before starting the analysis, we need to set up the Anaconda environment (see  NOTE 1 and  NOTE 2).

 NOTE 1: 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 (e.g. python) 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](http://www.jupyter.org)

 NOTE 2: 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/>

To create the same conda environment as the one used for the creation of this training material open *Terminal* in your RUS Virtual Machine and copy-paste the following command. Then, press *Enter* to run it (this step may take several minutes, do not interrupt it). The conda environment will be called *env\_r01*.

```
conda env create -f /shared/Training/R01_Sentinel2Processing_R/AuxData/environment.yml
```

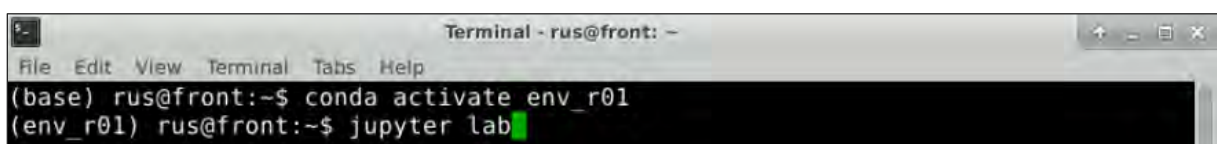
## 5.3 Sentinel-2 Processing using R - JupyterLab

Once the conda environment has been properly generated, we can start our exercise. Activate the *env\_r01* conda environment by running the following script in a new Terminal window.

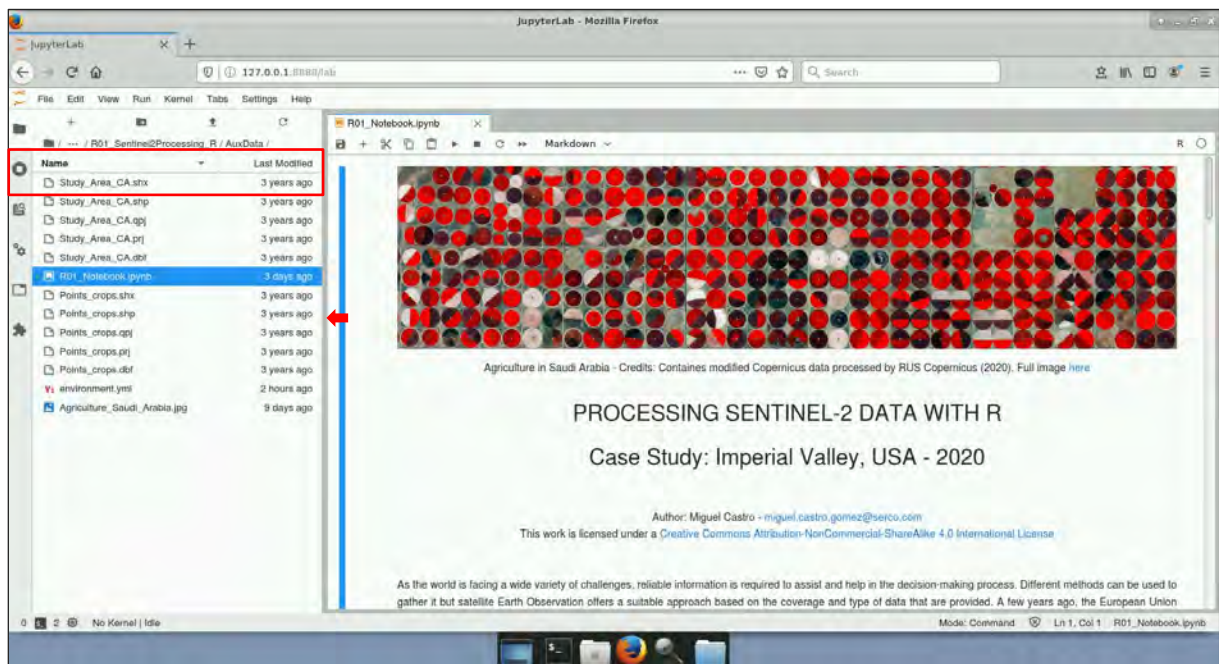
```
conda activate env_r01
```

Next, write Jupyter Lab and press enter to launch the application. Once open, navigate to the following path inside the JupyterLab GUI and open the file *R01\_Notebook.ipynb*

```
jupyter lab
```



Path: */shared/Training/R01\_Sentinel2Processing\_R/AuxData/*



Follow the instructions in JupyterLab to continue the exercise.

Notes



THANK YOU FOR FOLLOWING THE EXERCISE!

RUS-Copernicus Training website