

**TRAINING KIT – R02**

## **CROP MAPPING WITH SENTINEL-2 FOCUSING ON ALGORITHMS**

**Case Study: Seville 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 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

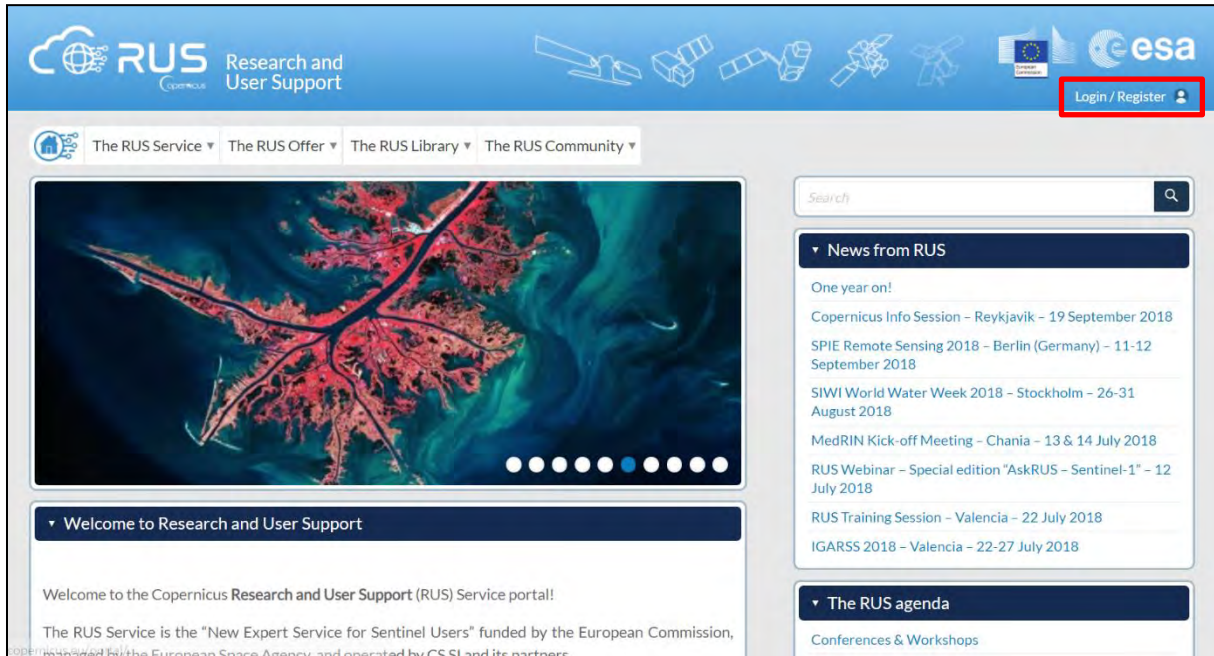
- 7 Sentinel-2A images acquired from June 1<sup>st</sup> until July 31<sup>st</sup> 2017 [downloadable at <https://scihub.copernicus.eu/> using the .meta4 file provided in the AuxData folder of this exercise]
- Pre-processed data stored locally  
@/shared/Training/R02\_CropMapping\_R/AuxData/

### 3.2 Software in RUS environment

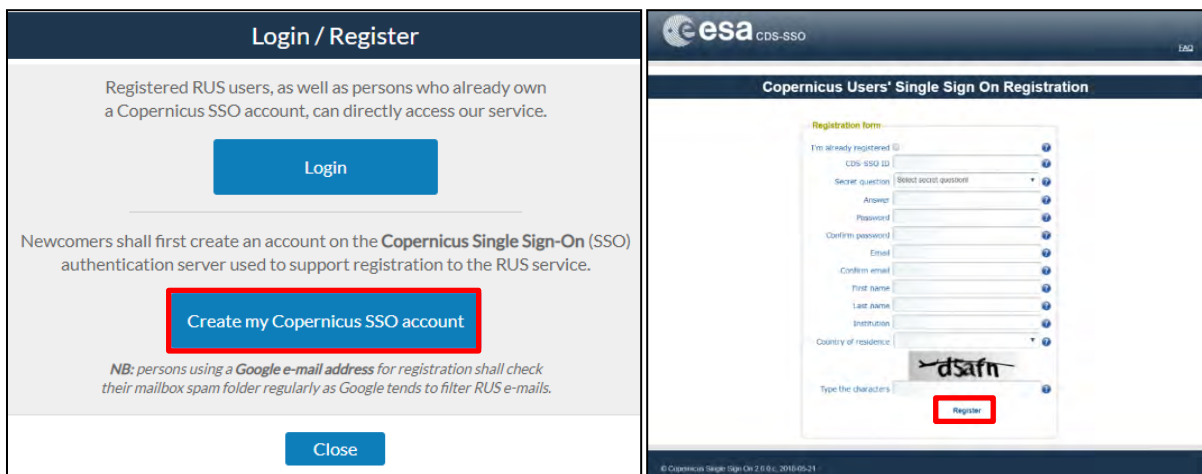
Internet browser, R + Jupyter Notebook

## 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](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:

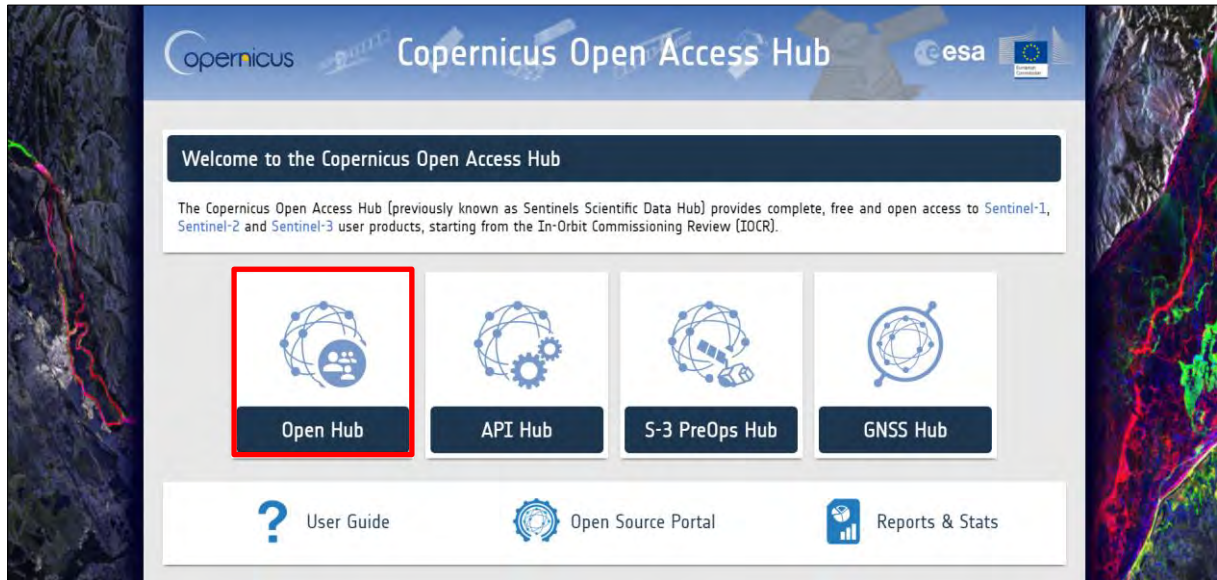
- Your profile: displays your personal information
- Your dashboard: allows you to manage your account
- Your training: allows you to register for training

## 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.


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 is a paragraph of text: "On completion of the registration form below you will receive an e-mail with a link to validate your e-mail address. Following this you can start to download the data. Username field accepts only alphanumeric characters plus '+', '-', '\_' and '.'." The form contains several input fields: "Firstname", "Lastname", "Username", "Password", "Confirm Password", "E-mail", "Confirm E-mail", "Select Domain", "Select Usage", and "Select Country". At the bottom of the form, there is a checkbox labeled "By registering in this website you are deemed to have accepted the T&C for Sentinel data use." and a "REGISTER" button. A red arrow points to the "SIGN UP" button in the top right corner of the page, and another red arrow points to the "REGISTER" button at the bottom right of the form.


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.

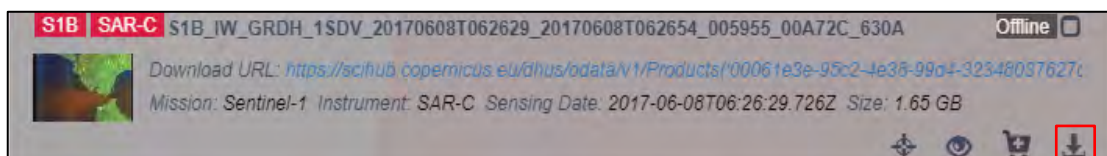
Once your account is activated – or if you already have an account – log in.




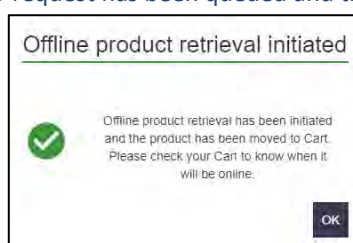
## 5.2 Download data

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/#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.

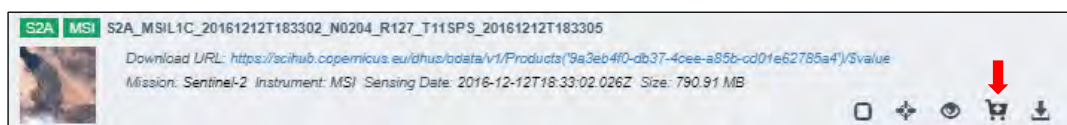


 NOTE 2: A download manager is a computer program dedicated to the task of downloading possibly unrelated stand-alone files from (and sometimes to) the Internet for storage. For this exercise, we will use aria2. Aria2 is a lightweight multi-protocol & multi-source command-line download utility. More info 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.

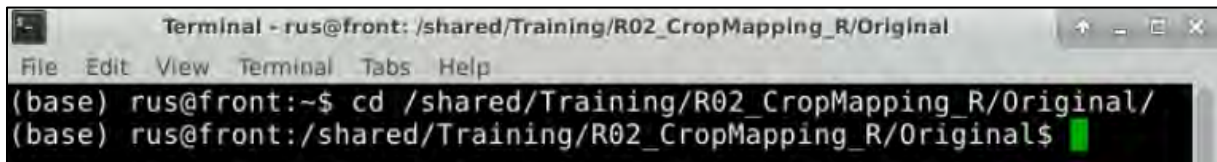
```
Terminal - rus@front-usr-231: ~  
File Edit View Terminal Tabs Help  
rus@front-usr-231:~$ aria2c  
Specify at least one URL.  
Usage: aria2c [OPTIONS] [URI | MAGNET | TORRENT_FILE | METALINK_FILE]...  
See 'aria2c -h'.  
rus@front-usr-231:~$
```

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

NOTE 4: If (**and only if**) the response is '*-bash aria2c: command not found*', you need to install aria2. In the command line, type: `sudo apt-get install aria2`  
When requested, type: `Y`  
Once finished, test the installation as explained before.

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/
```

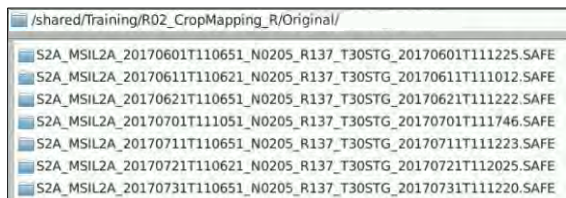


Next, type the following command (in a single line) to run the download tool. Replace *username* and *password* (leave the quotation marks) with your login credentials for Copernicus Open Access Hub (COAH). Do not clear your cart in the COAH until the download process is finished.



```
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.

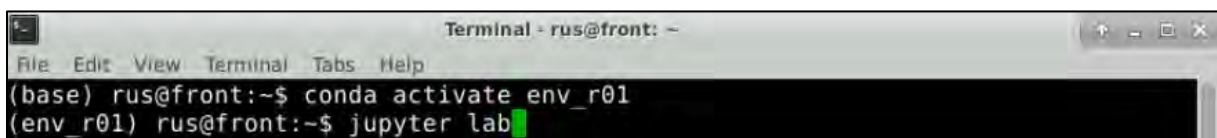
 NOTE 11: Project Jupyter is a non-profit, open-source project, born out of the IPython Project in 2014 as it evolved to support interactive data science and scientific computing across all programming languages. Notebook documents (or “notebooks”, all lower case) are documents produced by the Jupyter 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](http://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/>

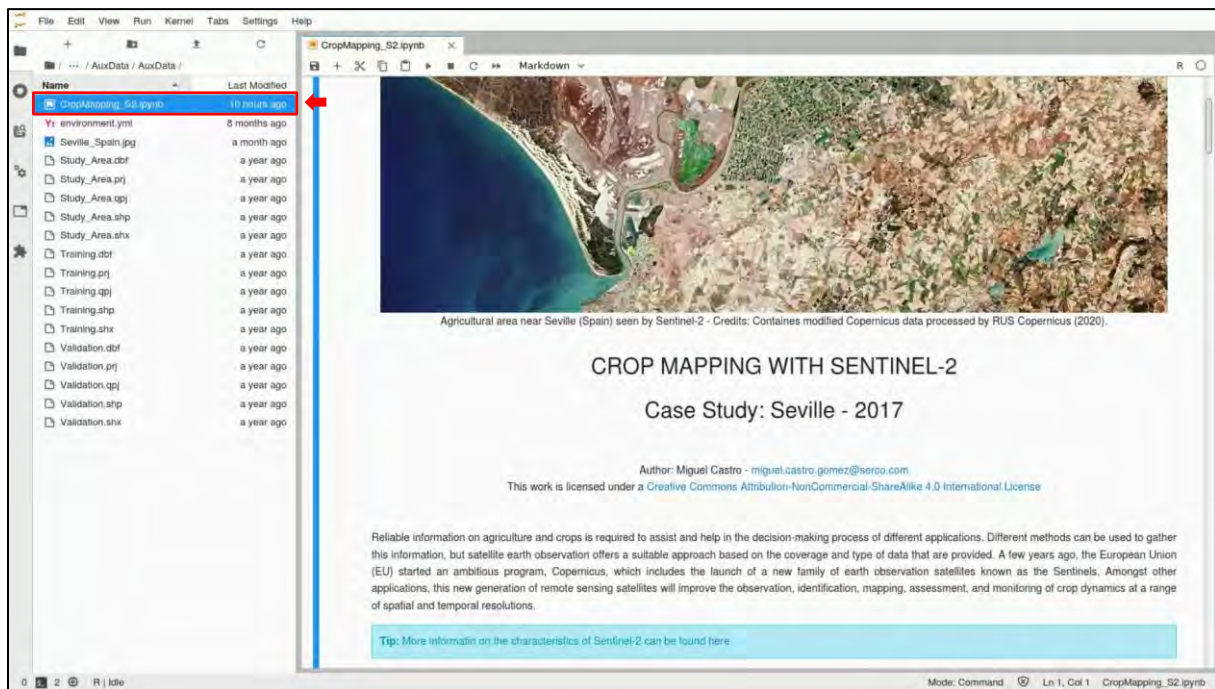
```
conda activate env_r01
```

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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