Exercise with EO Browser: Wildfires (Sentinel-1, Sentinel-2, Sentinel -5P)

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Learning goals

- Understand the negative and beneficial consequences of wildfires and how satellite imagery can be employed (Wildfires Case Study)
- Be introduced to the Normalised Burn Ratio (NBR) and to the Normalized Difference Vegetation Index (NDVI)
- Be introduced to the use of Themes in EO Browser
- Compare different images or products in EO Browser
- Be introduced to the use of custom scripts in EO Browser (with additional info on extending custom scripts, using URL and storing scripts)
- Learn how to upload/digitize polygons and obtain the extent of an area in EO Browser
- Display and interpret Sentinel-2 NDVI (L1C and L2A) time series in EO Browser
- Display and interpret Sentinel-5P CO and NO_2 maps in EO Browser
- Create a timelapse in EO Browser
- Display and interpret Sentinel-2 Moisture Index maps in EO Browser
- Be introduced to the challenges of using Sentinel-1 for fire scar mapping
- Display and interpret Sentinel-3 F1 Brightness Temperature maps in EO Browser

Summary

1. **Wildfires Case Study in EO Browser**:
    1. **Madeira**
    2. Siberia

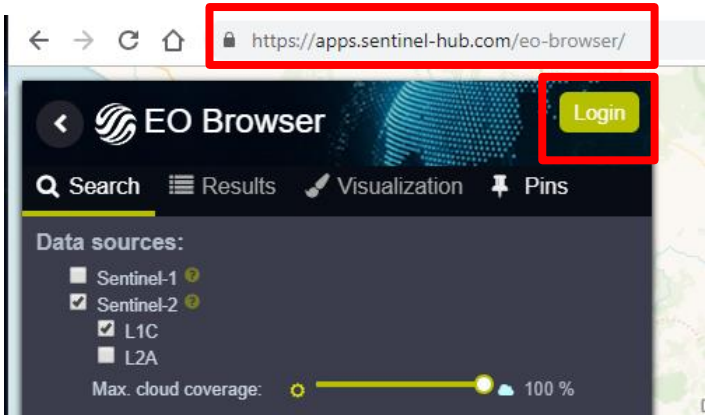
2. Wildfire in Madrid, Spain (July 2019)
    1. Sentinel-2: False Color, Moisture Index
    2. Sentinel-5P NO_2
    3. Sentinel-1
    4. Sentinel-3 F1 Brightness Temperature

1- Wildfires Case Study in EO Browser

http://apps.sentinel-hub.com/eo-browser/

Register **for free** with an email address, to have full access to all the tools.

Login with your username & password.

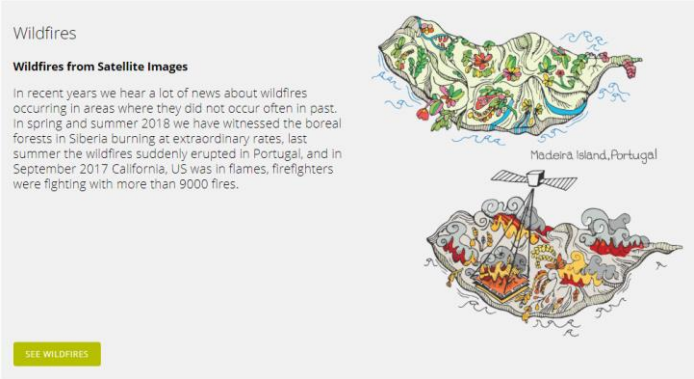


1- Wildfires Case Study in EO Browser

We will follow the **Wildfires Case Study** and repeat its steps **in parallel in EO Browser**.

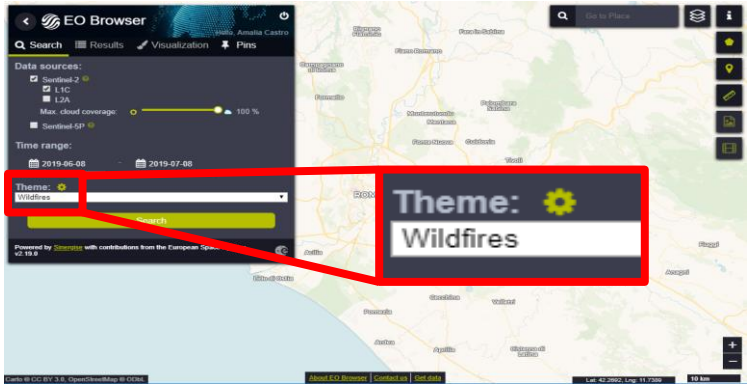
Open the **Wildfires Case Study**.

https://www.sentinel-hub.com/explore/education



+

Open the **EO Browser** and display the **Wildfires theme**.



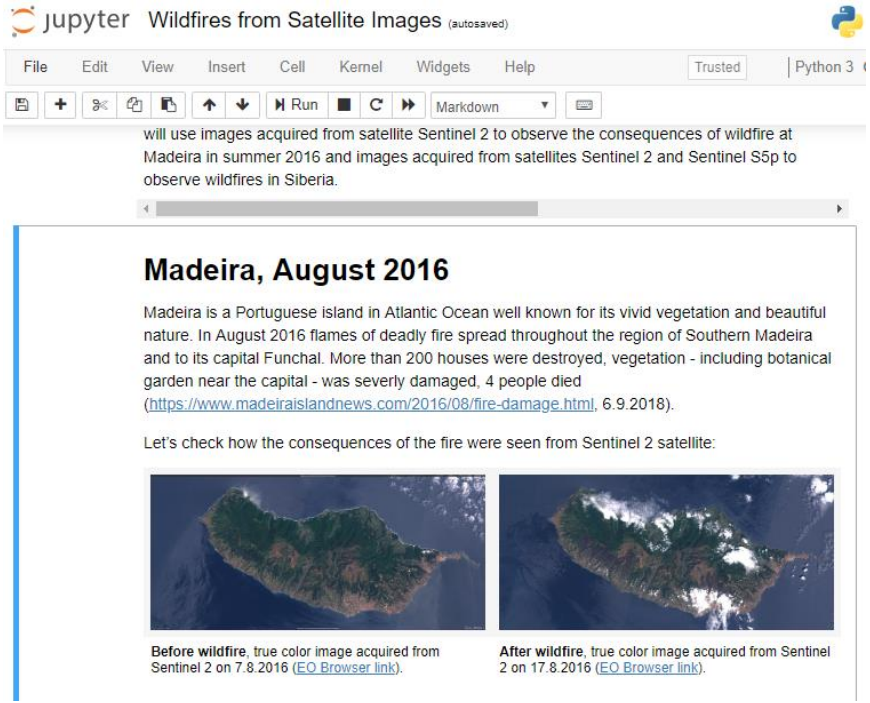
1- Wildfires Case Study in EO Browser

Look at the case study. The introduction gives a quick overview of the negative and beneficial consequences of wildfires. It explains **how satellite imagery can be employed**, and lists common uses.

In this case study we will check how some of the wildfires and their consequences can be seen from space:
- Madeira fires in summer 2016 (**S2**)
- Siberian fires in summer 2018 (**S2 and S-5P**)

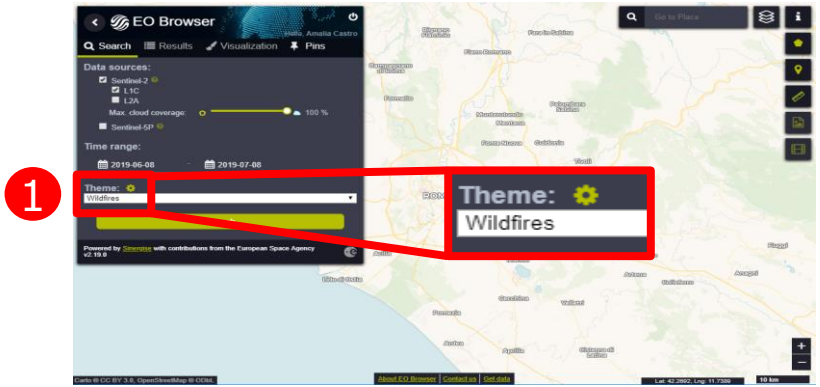
1- Wildfires Case Study in EO Browser

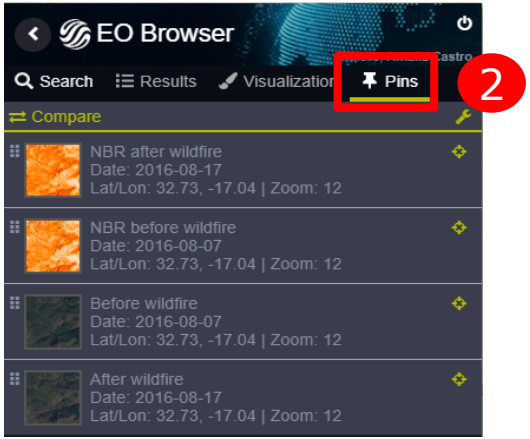
Read the **introduction** of the case study and read about the **Normalised Burn Ratio (NBR).**



1- Wildfires Case Study in EO Browser

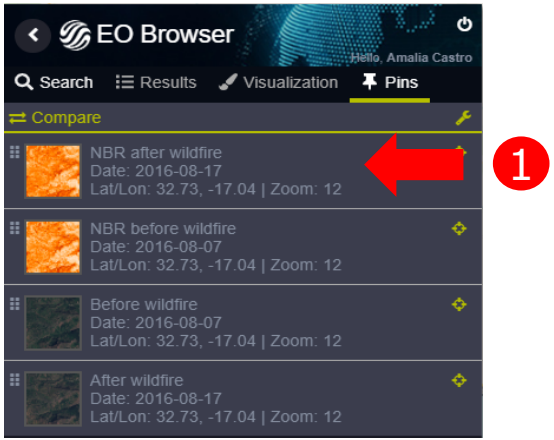
In the **EO Browser Wildfires theme**, click **Pins**. You will see a selection of S2 images acquired over Madeira before and after the fire shown in the Wildfires Case Study, and includes **their corresponding Normalised Burn Ratio (NBR).**

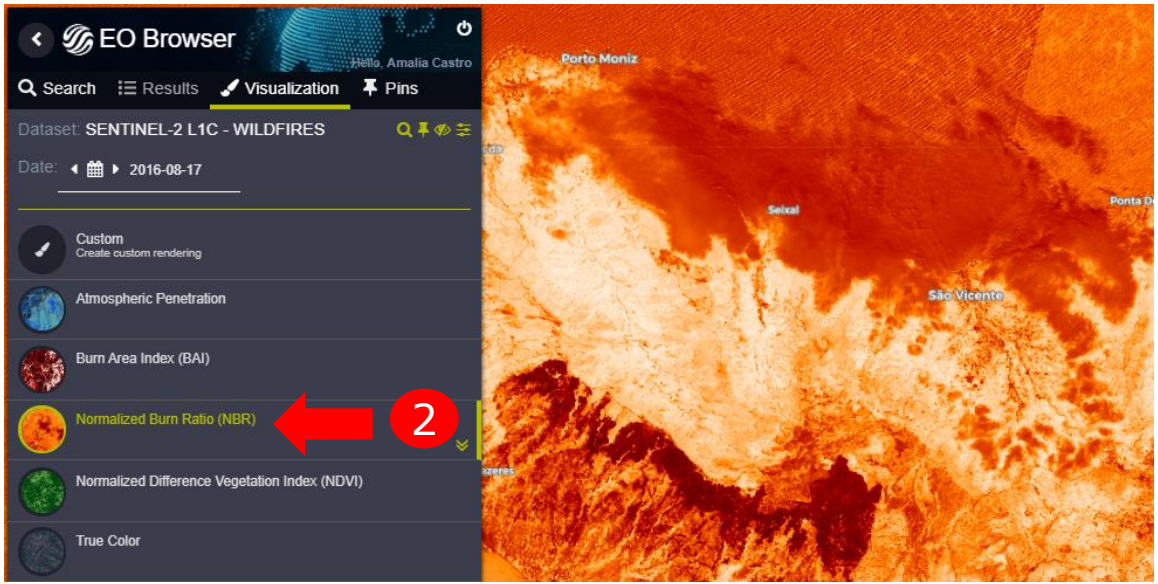




1- Wildfires Case Study in EO Browser

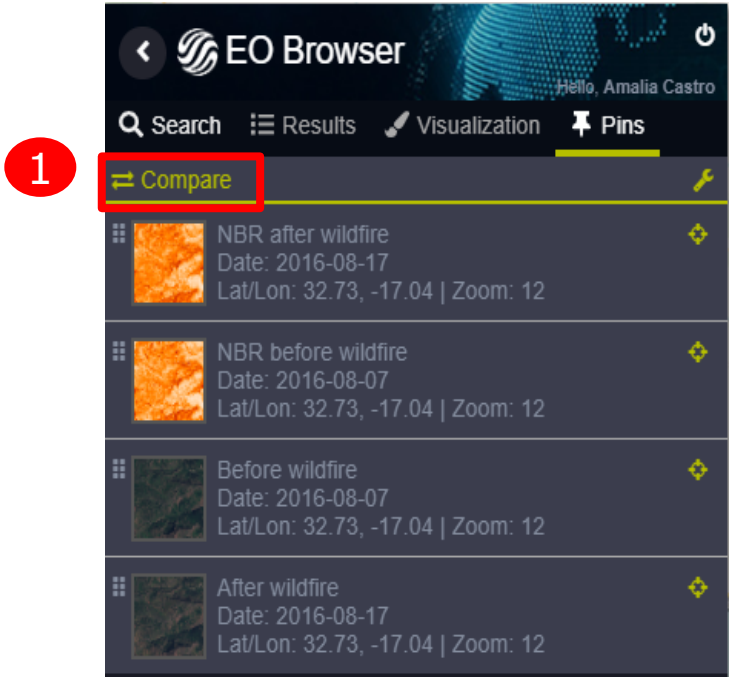
Click on one of the **NBR images**, and it will **display**.





1- Wildfires Case Study in EO Browser

Compare the images taken **before and after** the fire by clicking **Compare** and adjusting in your preferred way the **Opacity sliders**.



1- Wildfires Case Study in EO Browser

If you wanted to **calculate the NBR** yourself, you would need to:

1. Come out from the Wildfires Theme into the **Default Theme**
2. Search for the S2 image of your choice (e.g. over **Madeira in 2016-08-17**)
3. Visualize it
4. Choose **Custom** view
5. Enter the custom script: return [(B08-B12)/(B08+B12)];
6. Press **Refresh**.

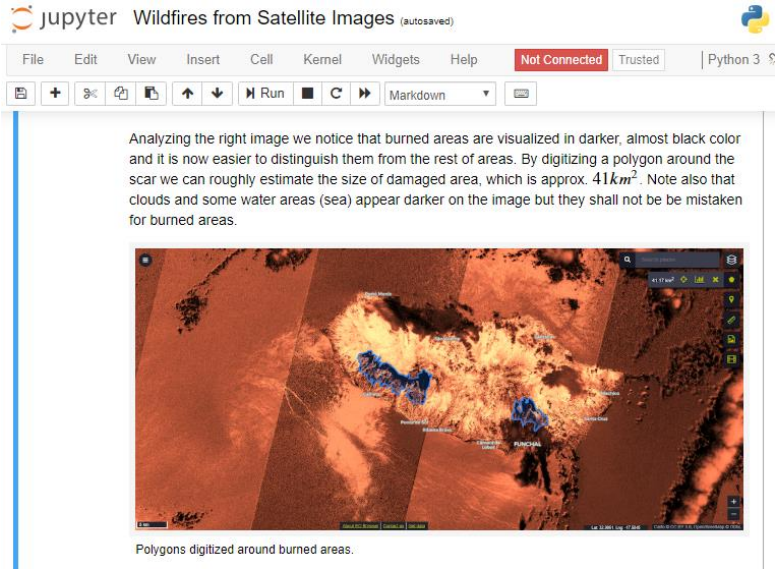
However this would **not assign a colour scale to your result**, which is only possible if we **extend the custom script**. More information on how to assign a continuous colour scale with the *colorBlend* function:

- For **programmers**: https://www.sentinel-hub.com/develop/documentation/api/custom-evaluation-script (at the bottom of the page)

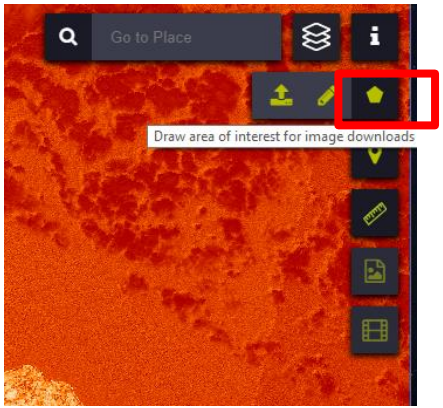
- For **non-programmers**, a simplified version of the tutorial above can be found at https://sentinel-hub.com/sites/default/Custom_script_tutorial.pdf, see chapter 5.2.

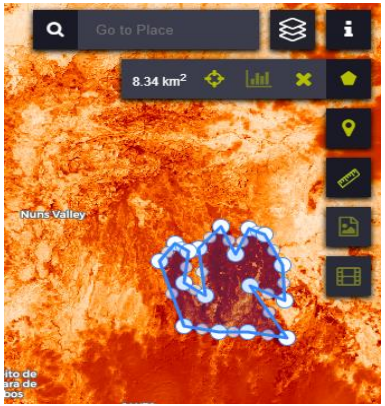
1- Wildfires Case Study in EO Browser

In the Case Study, read about the **digitization of polygons** around burned areas.



In EO Browser, **draw an AOI** around the **two burned areas**, and read their **extent**. The larger area is around 36 km^2 and the smaller one is around 8 km^2.

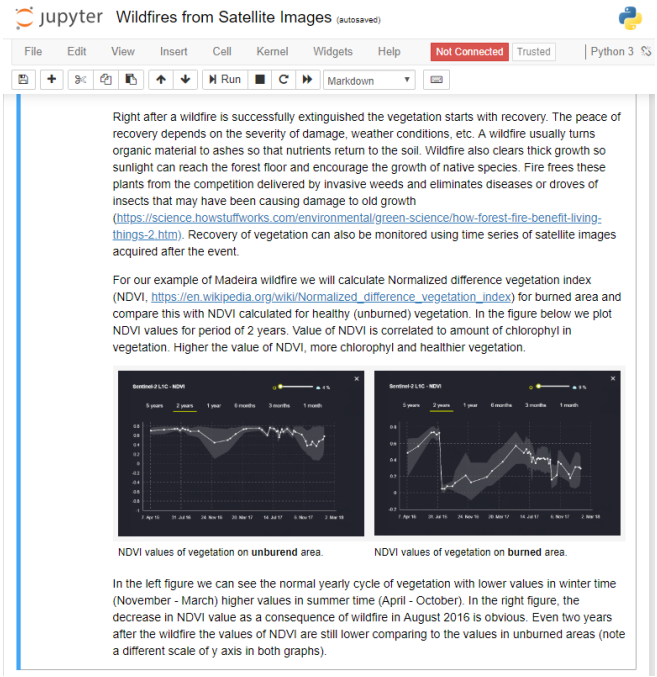




Note that within EO Browser it is only possible to digitize **a single polygon at once**. However, a multi-polygon KML can be created outside EO Browser (e.g. Google Earth) and be uploaded to EO Browser.

1- Wildfires Case Study in EO Browser

In the Case Study, read about **the NDVI time series** over burned and unburned areas.



jupyter Wildfires from Satellite Images (autosaved)

File Edit View Insert Cell Kernel Widgets Help Not Connected Trusted Python 3

Run Markdown

Right after a wildfire is successfully extinguished the vegetation starts with recovery. The peace of recovery depends on the severity of damage, weather conditions, etc. A wildfire usually turns organic material to ashes so that nutrients return to the soil. Wildfire also clears thick growth so sunlight can reach the forest floor and encourage the growth of native species. Fire frees these plants from the competition delivered by invasive weeds and eliminates diseases or droves of insects that may have been causing damage to old growth (https://science.howstuffworks.com/environmental/green-science/how-forest-fire-benefit-living-things-2.htm). Recovery of vegetation can also be monitored using time series of satellite images acquired after the event.

For our example of Madeira wildfire we will calculate Normalized difference vegetation index (NDVI, https://en.wikipedia.org/wiki/Normalized_difference_vegetation_index) for burned area and compare this with NDVI calculated for healthy (unburned) vegetation. In the figure below we plot NDVI values for period of 2 years. Value of NDVI is correlated to amount of chlorophyl in vegetation. Higher the value of NDVI, more chlorophyl and healthier vegetation.

NDVI values of vegetation on **unburend** area.

NDVI values of vegetation on **burned** area.

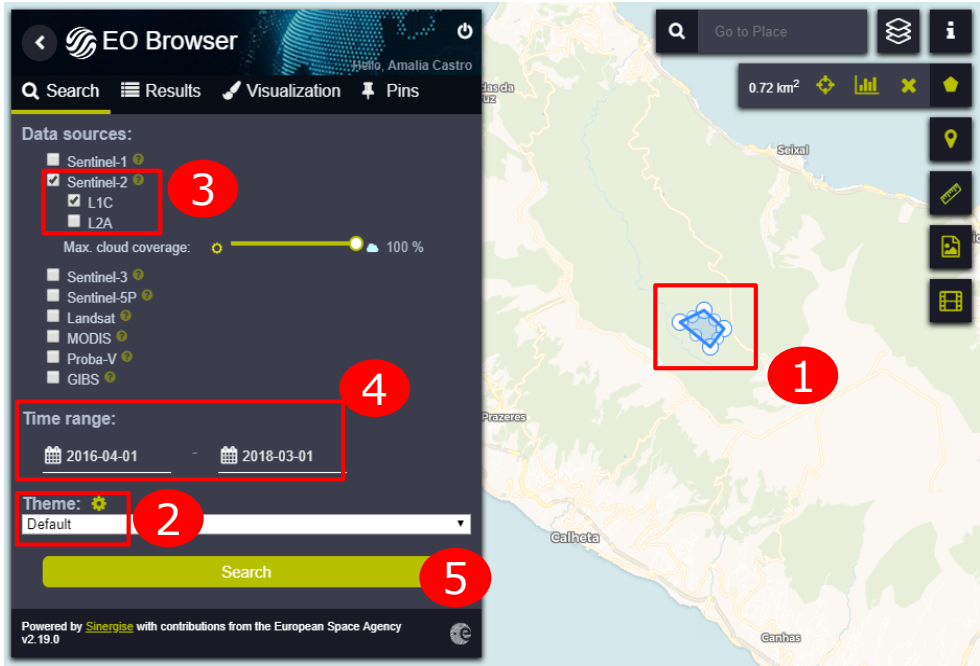
In the left figure we can see the normal yearly cycle of vegetation with lower values in winter time (November - March) higher values in summer time (April - October). In the right figure, the decrease in NDVI value as a consequence of wildfire in August 2016 is obvious. Even two years after the wildfire the values of NDVI are still lower comparing to the values in unburned areas (note a different scale of y axis in both graphs).

1- Wildfires Case Study in EO Browser

Note that in the **Wildfires Theme** it is **not possible to display time series** (the feature is not yet available).

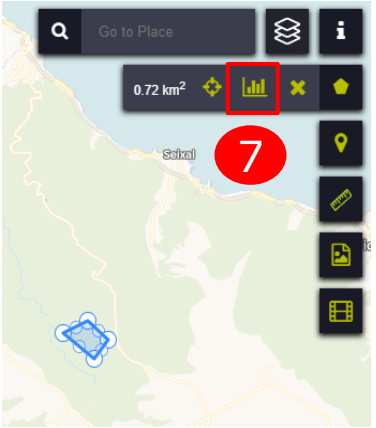
So to reproduce the steps taken in the Case Study:

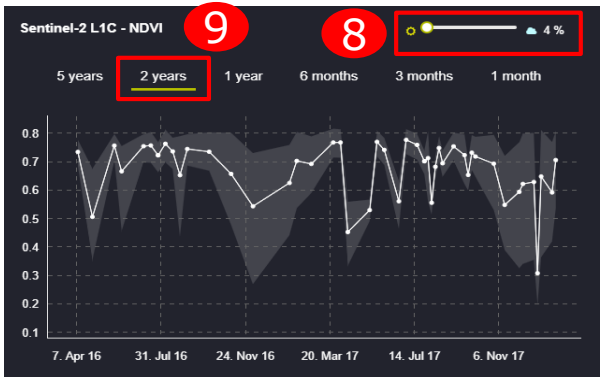
1. Make sure you have an **AOI drawn** over the burned area (it can be a small section of the burned area)
2. In Search, under Theme choose **Default** (not Wildfire)
3. As Data sources, keep **Sentinel-2 L1C**
4. Next we need to display an image. However, it can be **any image**, because this will simply allow us to access the Time Series tool. Once inside the tool, the time range (i.e. how far back in time the time series goes) can be adjusted. You could enter the same time range as the wildfire case study, for example.
5. Click **Search**



1- Wildfires Case Study in EO Browser

6. In any of the images that appear as a result, click **Visualize** and select the **NDVI layer**.
   Remember this is just needed so that we can access the Time Series tool.
7. Click the **Statistical info** of the AOI
8. The graph will appear. Adjust the **maximum cloud cover** down to 4%
9. Select **2 years**

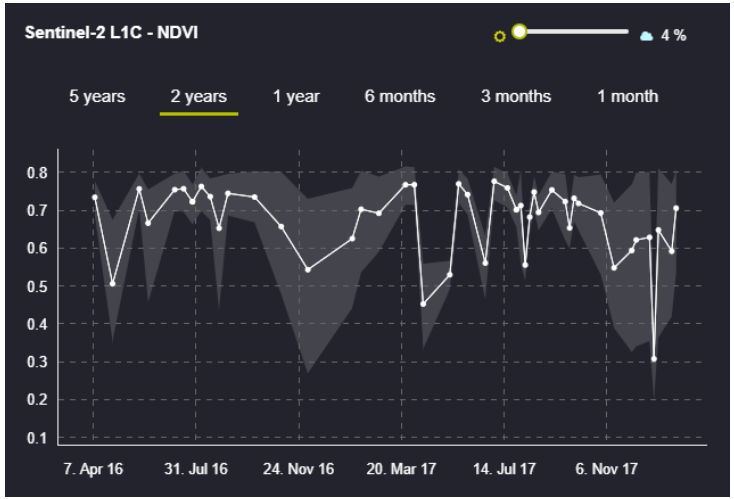




Repeat for **unburned areas**, by following the same steps but this time, with an AOI drawn over areas not affected by the fire.

In the next slide we see the results of both.

1- Wildfires Case Study in EO Browser



Unburned area

Burned area

We can clearly see the **abrupt drop in the NDVI values** due to the **fire event**, and the **slow recovery of vegetation** that followed afterwards.

Summary

1. **Wildfires Case Study in EO Browser**:
    1. Madeira
    2. **Siberia**

2. Wildfire in Madrid, Spain (July 2019)
    1. Sentinel-2: False Color, Moisture Index
    2. Sentinel-5P NO_2
    3. Sentinel-1
    4. Sentinel-3 F1 Brightness Temperature

1- Wildfires Case Study in EO Browser

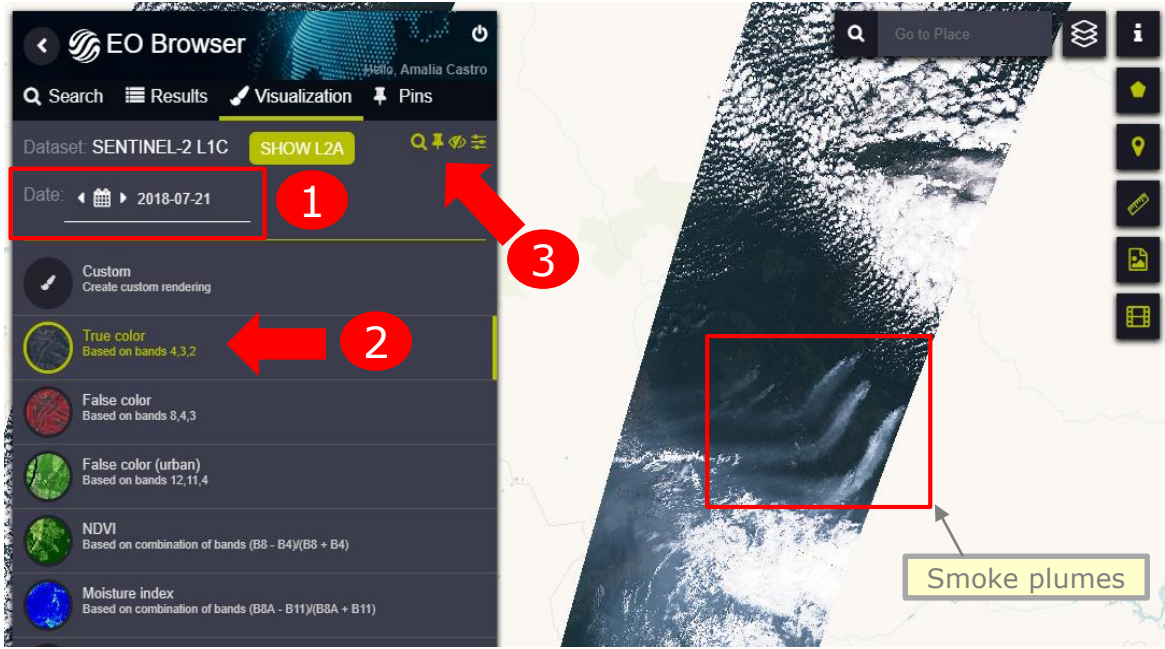
Wildfires started in Siberia in mid July 2018.

In this section we will learn **how to use a script in the EO Browser**, to modify the visualization.

1. In Search, look for a **Sentinel-2 L1C** image from **2018-07-21** in Siberia, in the area **north of Krasnoyarsk.** You will see the smoke plumes of the fires

2. Display the **True Colour** option

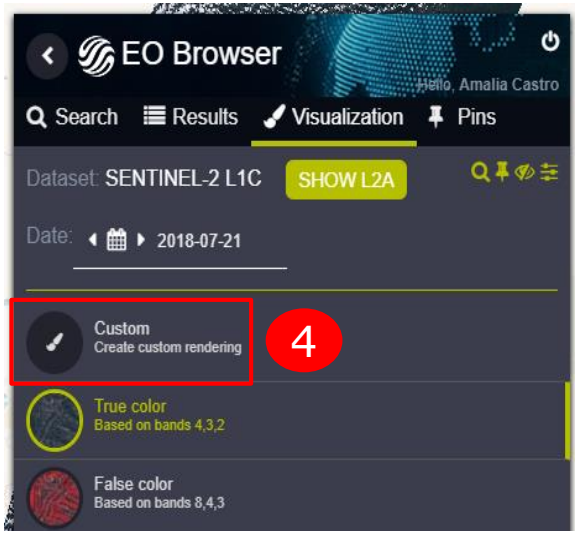
3. **Pin it** (we save the image to use it later on for comparison)

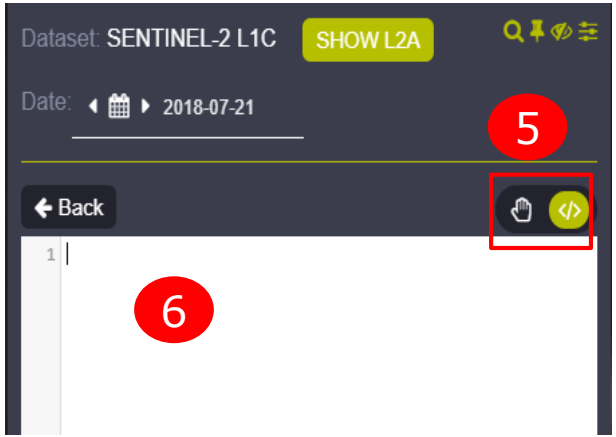


1- Wildfires Case Study in EO Browser

Let's see where the script will be entered:

4. Click **Custom**
5. Select the **script symbol** (not the hand symbol)
6. **Delete the pre-existing** script

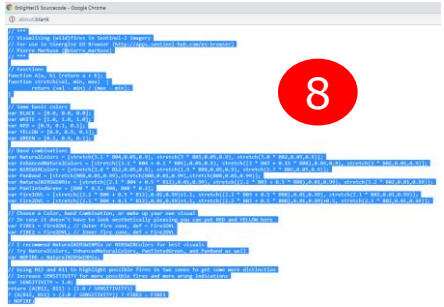




1- Wildfires Case Study in EO Browser

Now let's get the **script from Pierre Markuse**, which **enhances the visualization of active fires**. His **first version** (also accessible from the Case Study) is https://pierre-markuse.net/2017/08/07/visualizing-wildfires-sentinel-2-imagery-eo-browser/.

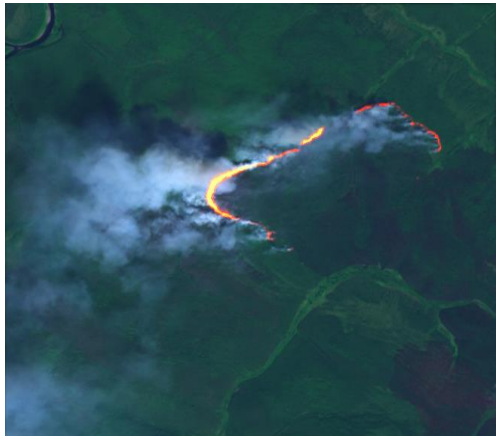
7. Navigate to the site above. At the script section, top right, select **Open Code in New Window**
8. **Copy** the script
9. Back in **EO Browser**, **paste it** in the white area
10. Click **Refresh.** The display will adjust to show the result of the script
11. **Pin** the result



1- Wildfires Case Study in EO Browser

Additionally, you can repeat the steps for the **second version of the script**, and **pin** the result. Below are the results from the two versions of the scripts.

True Colour



Custom script from Pierre Markuse (first version)

Custom script from Pierre Markuse (second version)

1- Wildfires Case Study in EO Browser

Additional info:

Temporal scripts

Note that at the moment, **custom scripts** (also called "evalscripts" in EO Browser) can only use **one data source (the input needs to be a single image).** In the future there are plans to upgrade this.
Scripts that can combine data from different dates (i.e. **temporal scripts**) can only be used in **Sentinel Playground**.

Use URL

If you have your script at some URL you can check "**Use URL**", paste the URL pointing to the script (if you use a script in GitHub: open a script on GitHub, then click "Raw" and copy the URL) into EO Browser, and click "Refresh" (little arrows in a circle). This shall copy the script from URL to EO Browser and then you **work with it as if you inputted the script directly in EO Browser**. Sinergise has some **examples of scripts** stored here: https://github.com/sentinel-hub/custom-scripts.

Storing scripts

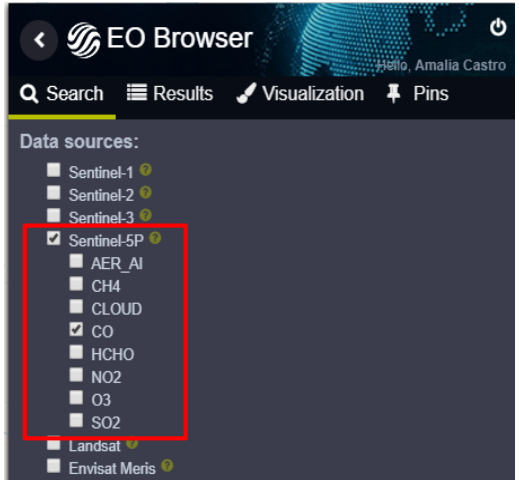
Each user can store their own scripts in **Configuration Utility**, accessible from here: https://apps.sentinel-hub.com/dashboard/#/. Log in with Sentinel Hub account and click the second icon on your left: "Configuration Utility". Here you can can create **your own themes and layers**. More info in the **User guide**: https://www.sentinel-hub.com/develop/capabilities/configuration_utility/configuration-utility-user-guide.

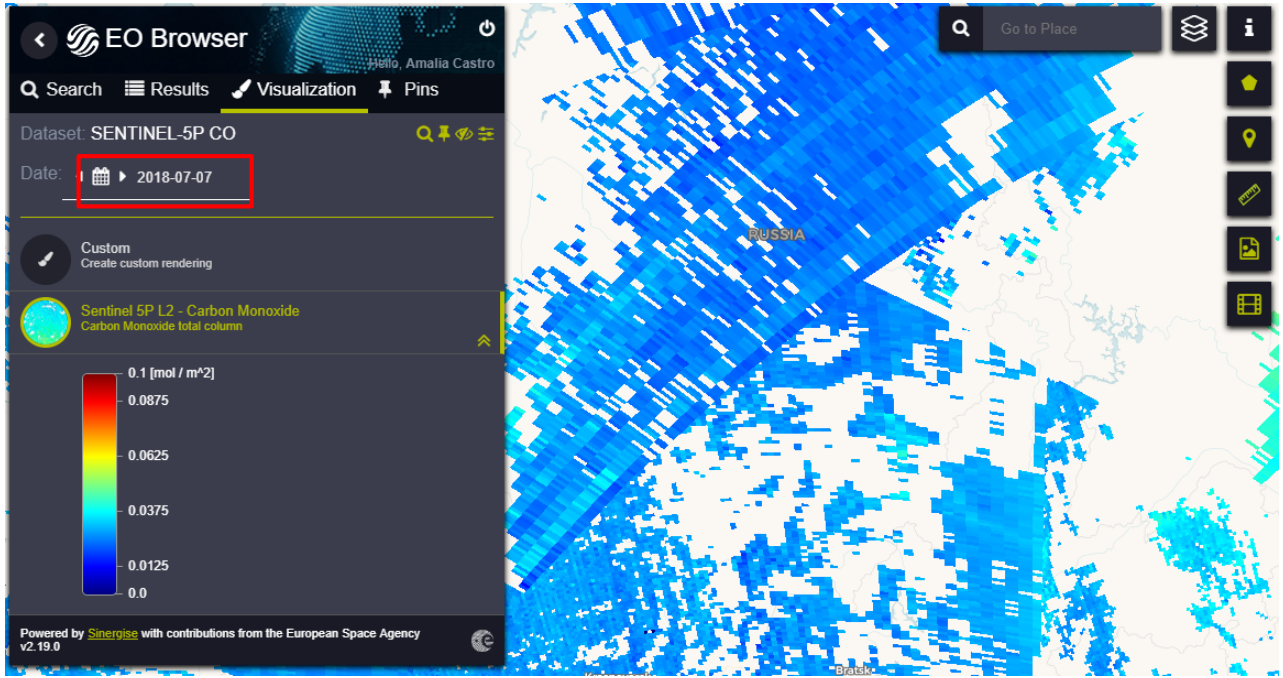
1- Wildfires Case Study in EO Browser

Let’s have a look at the **atmospheric emissions** of those fires, using **Sentinel-5P**.

1- Wildfires Case Study in EO Browser

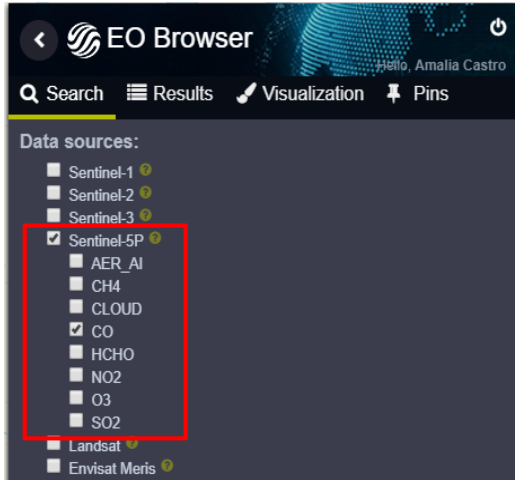
Select **Sentinel-5P Carbon Monoxide** map (**CO**) from **2018-07-07** (before the fire):

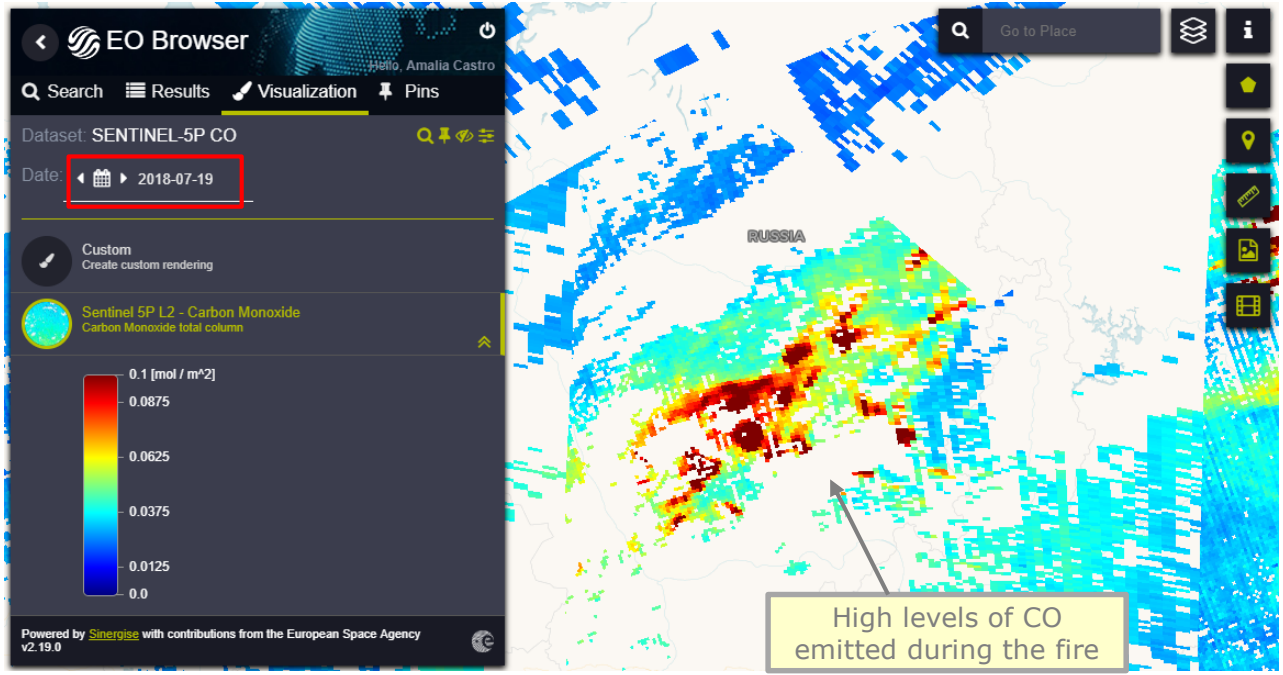




1- Wildfires Case Study in EO Browser

And select **Sentinel-5P Carbon Monoxide** map (**CO**) from **2018-07-19** (during the fire):

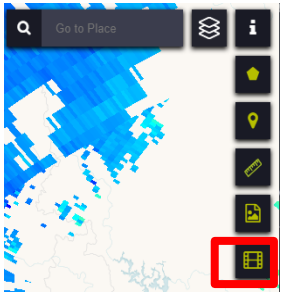


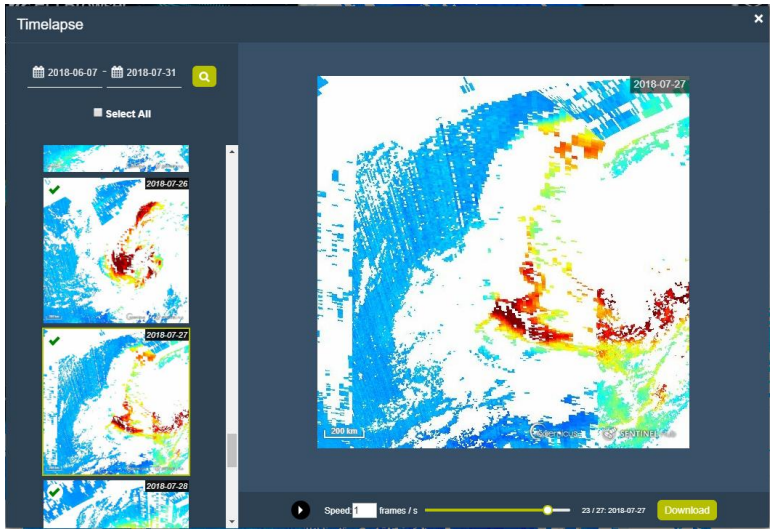


1- Wildfires Case Study in EO Browser

A **Timelapse** can be a good way to visualize the evolution over an area:

1. Go to the **Create Timelapse Animation** button (right section of the EOBrowser screen)
2. Select the **time range** we are interested in (from early to end of July 2019)
3. Click **Search**
4. Scroll down the images and keep selected only those that **do not have gaps over our area**
5. Select the **Speed** of frames
6. Preview and once we are happy with it, **Download**





Summary

1. Wildfires Case Study in EO Browser:
    1. Madeira
    2. Siberia

2. **Wildfire in Madrid, Spain (July 2019)**
    1. Sentinel-2: False Color, Moisture Index
    2. Sentinel-5P NO_2
    3. Sentinel-1
    4. Sentinel-3 F1 Brightness Temperature

2- Wildfire in Madrid (July 2019)

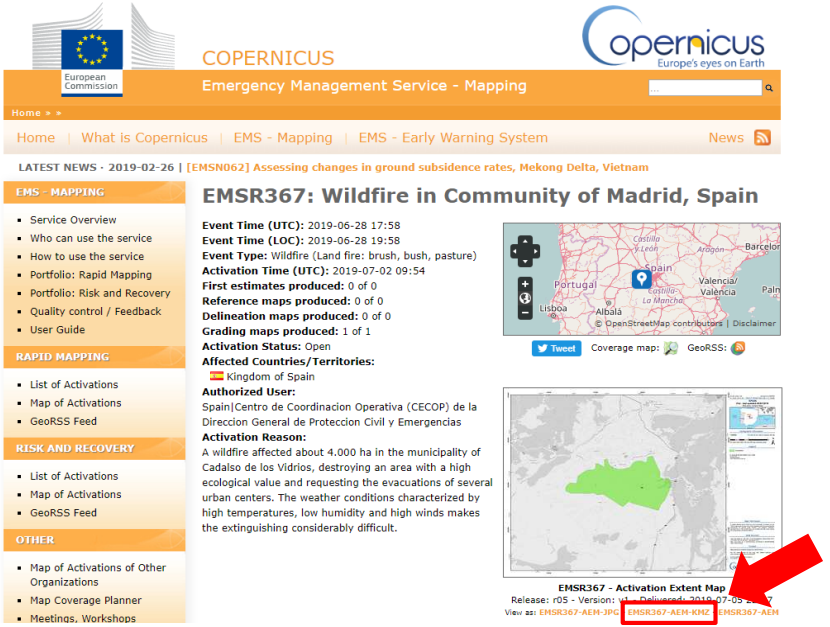
Now we will show an example of a **recent fire**, where we can have images from **Sentinel-2, 3 and 5-P**:

Image from the event, taken in July 2019

(source: El Pais)

Navigate to the site of this emergency activation on the **Copernicus Emergency Management Service**. Download the KMZ of the area affected.

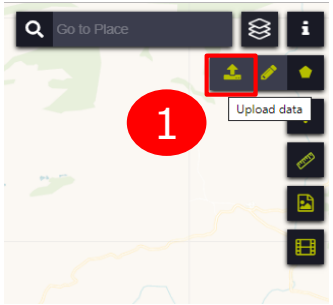
https://emergency.copernicus.eu/mapping/list-of-components/EMSR367

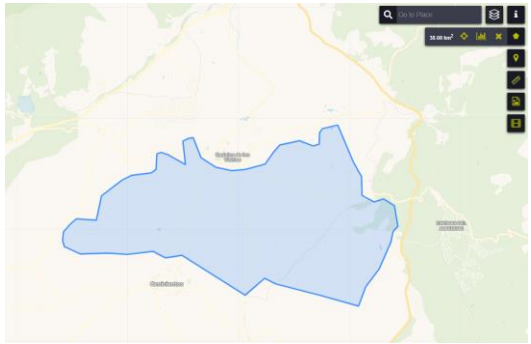


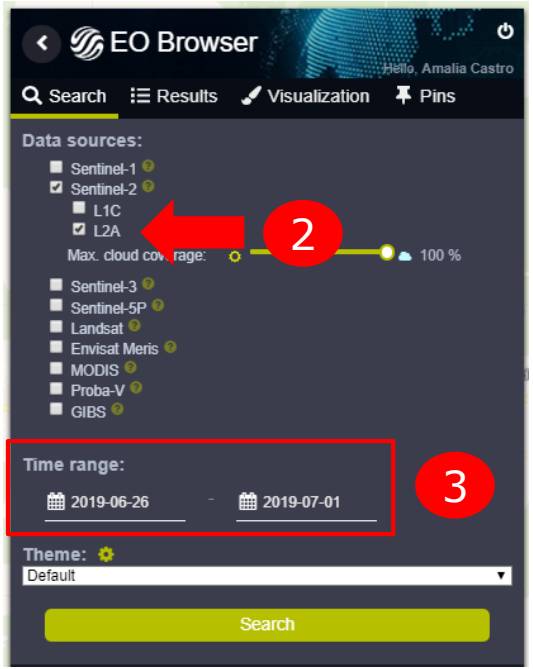
2- Wildfire in Madrid (July 2019)

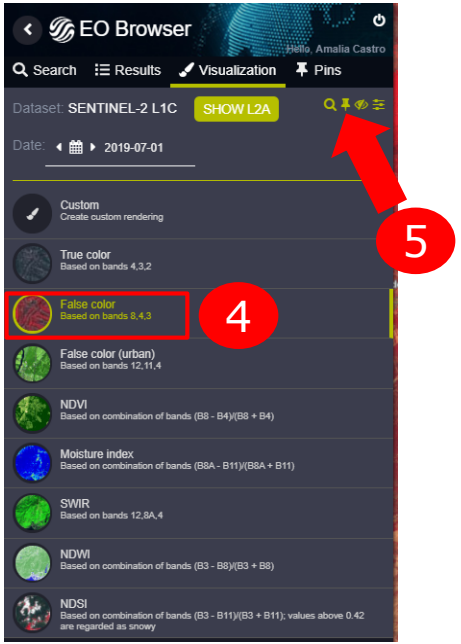
In the EO Browser, go to **Area of Interest** and click **Upload Data** to import your kmz.

Search for images from **Sentinel-2 before (2019-06-26)** and **after the event (2019-07-01)**, and display each them in **False Colour** (Bands 8, 4 and 3). You can use the **Pin** function to save the displays.





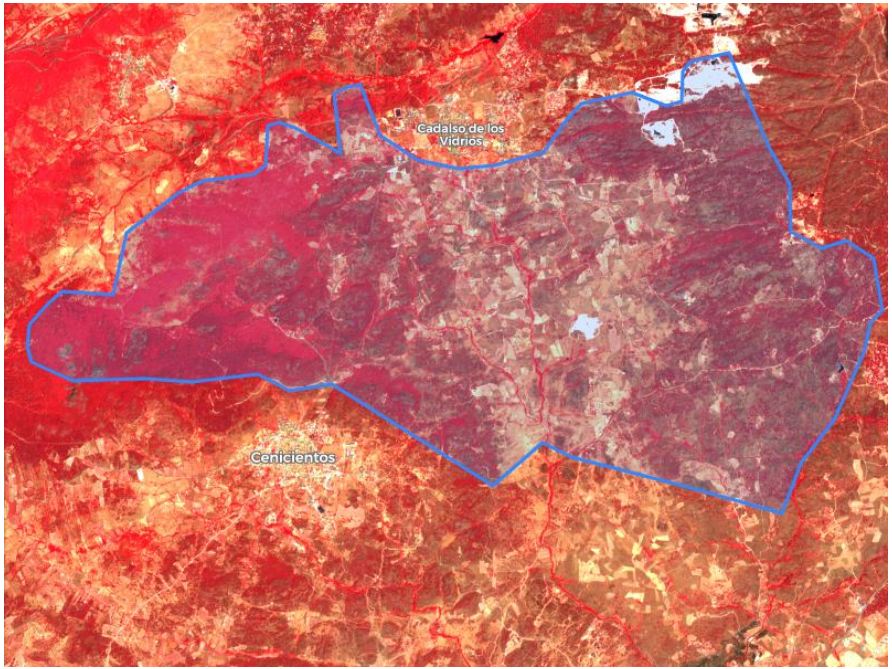




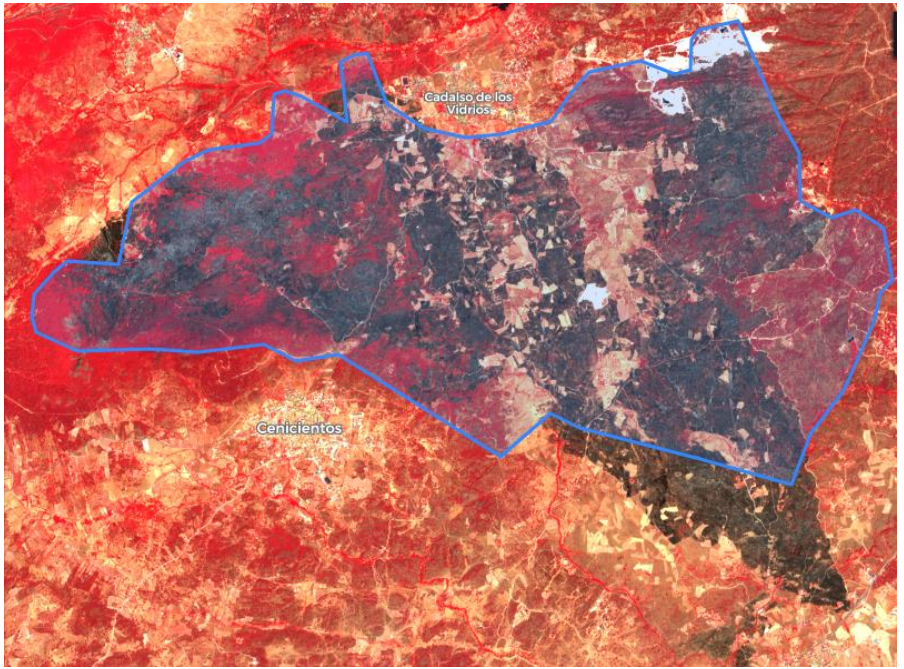
2- Wildfire in Madrid (July 2019)

Here are the two results. Notice the **burn scar** on the right one.

2019-06-26 (before the fire)



2019-07-01 (after the fire)



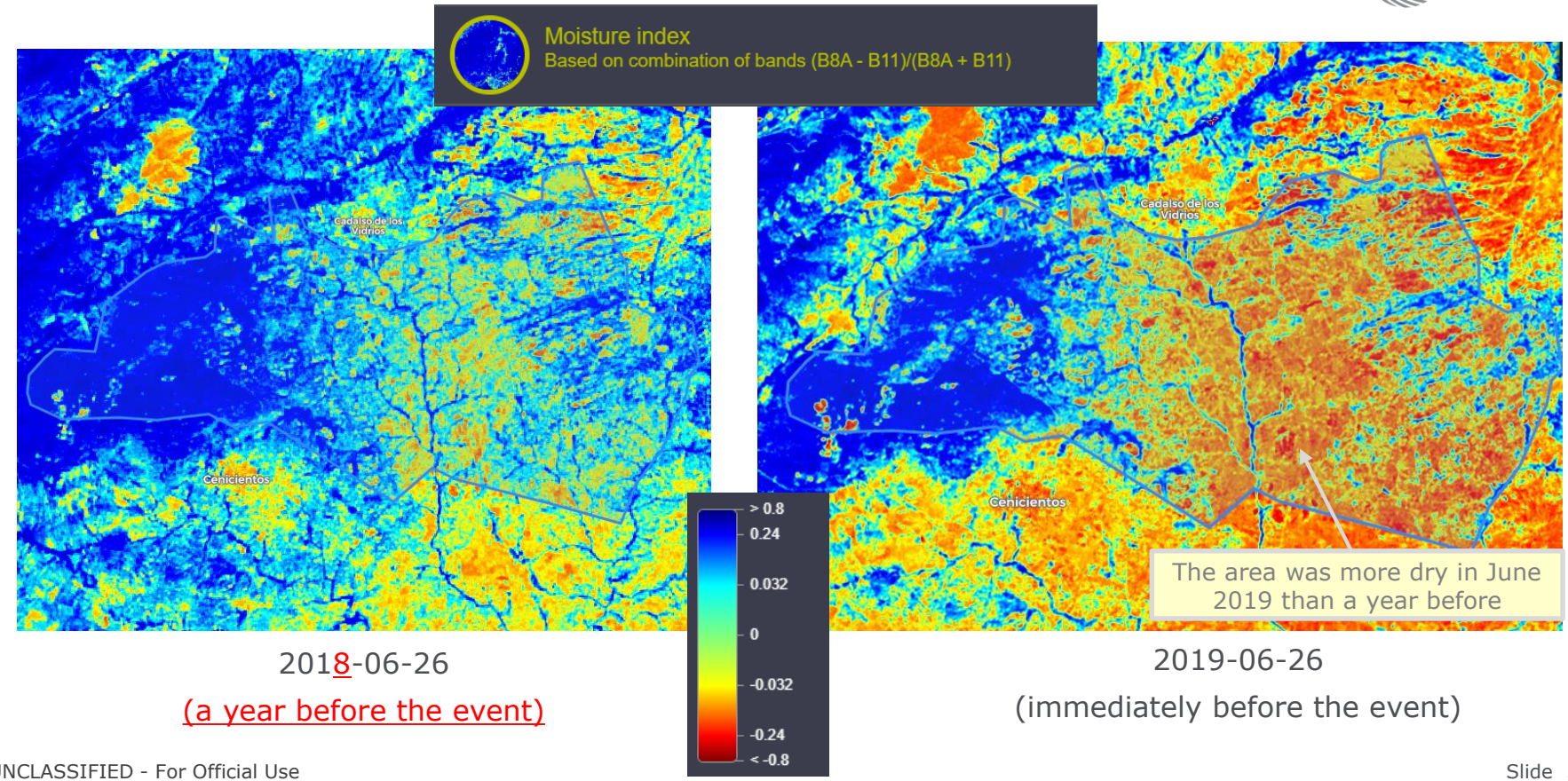
2- Wildfire in Madrid (July 2019)

Repeat the procedure displaying this time the **Sentinel-2 Moisture Index** visualization **for each of the images**. Use the **Pin** function to save the displays.

We also display the **Moisture Index** an image from **2018-06-26**, a year before the event. **Pin** it.

The next slides show the results.

2- Wildfire in Madrid (July 2019)



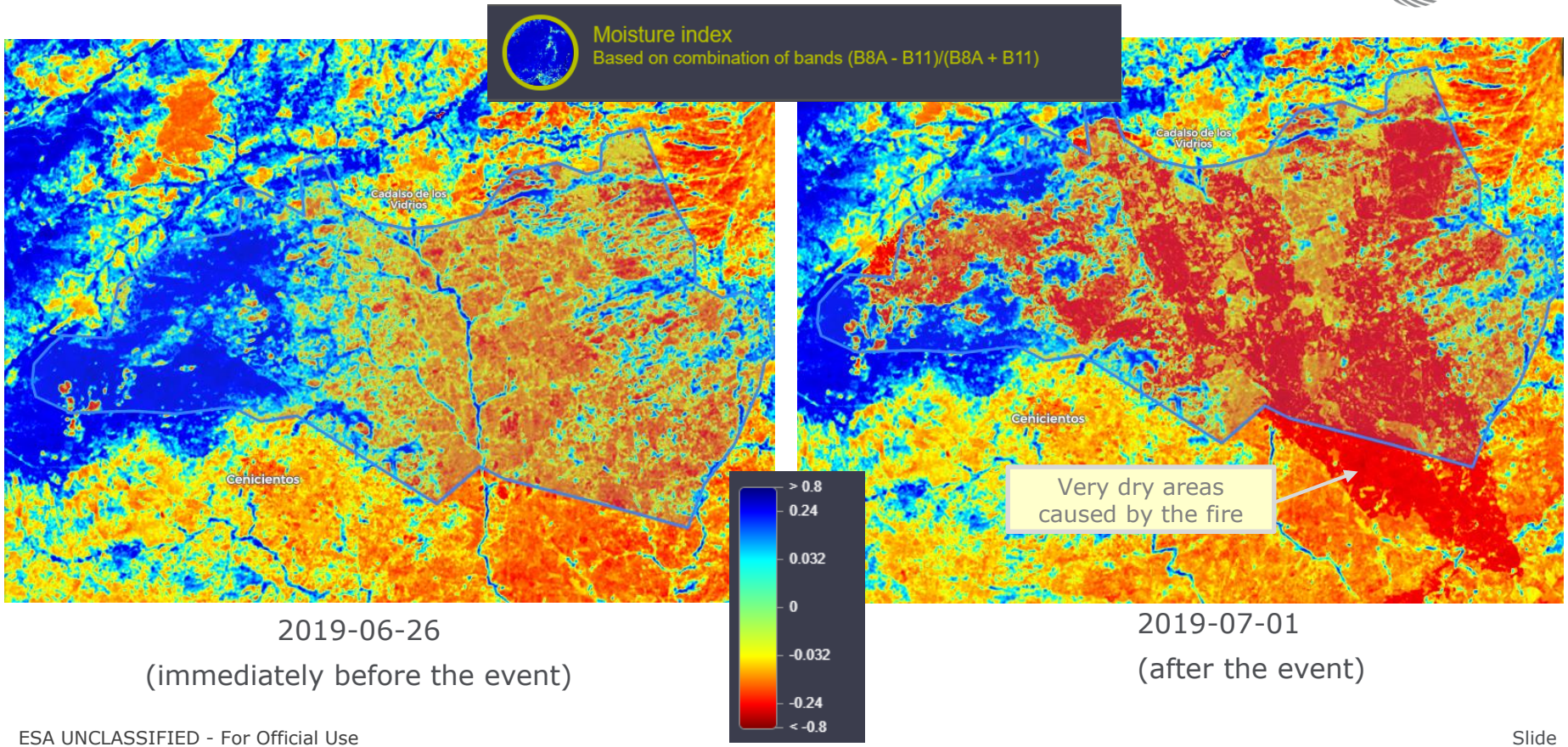
2018-06-26

(a year before the event)

2019-06-26

(immediately before the event)

2- Wildfire in Madrid (July 2019)



2019-06-26

(immediately before the event)

2019-07-01

(after the event)

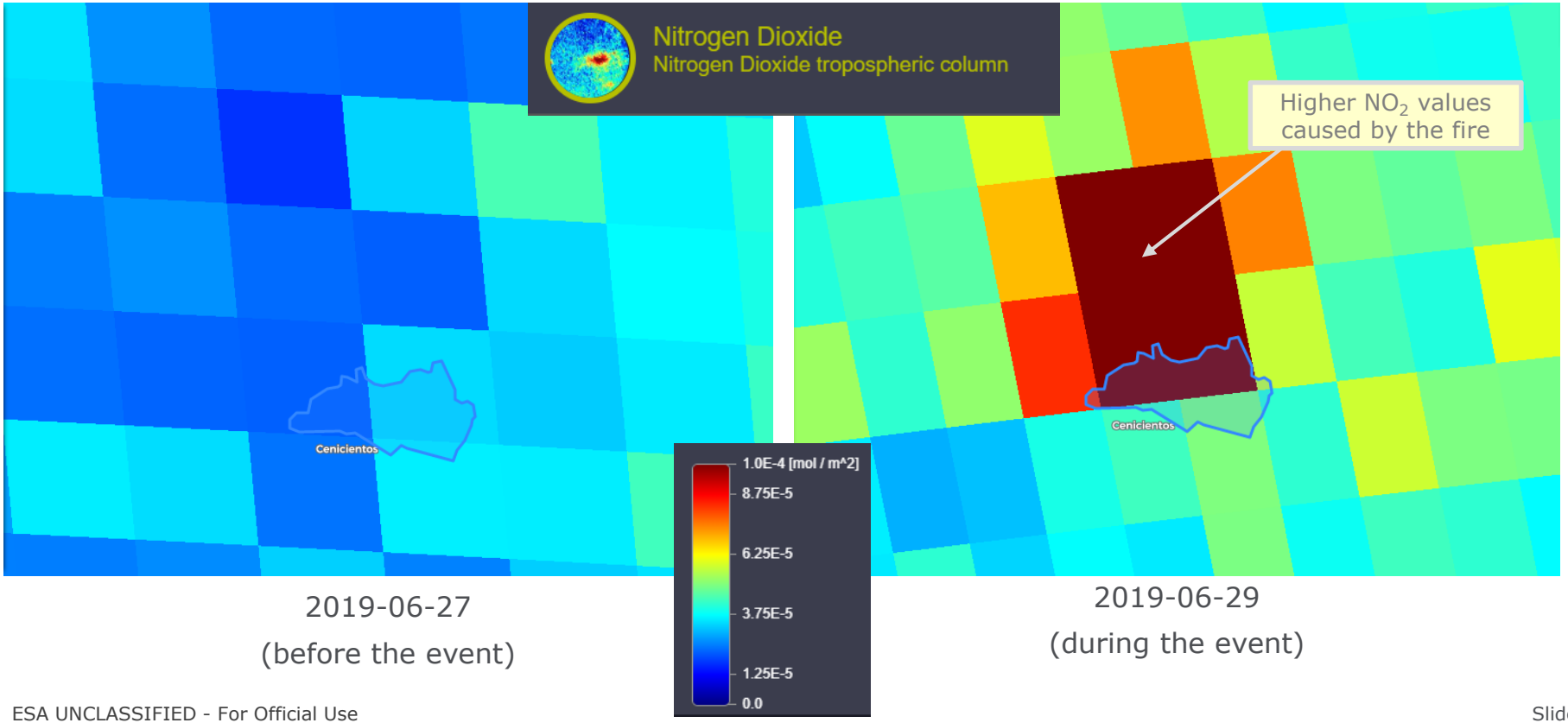
2- Wildfire in Madrid (July 2019)

Let's visualise as well the emissions of **NO_2** in the area, using **Sentinel-5P**. Search for the image from **2019-06-27 (before the event)** and from **2019-06-29 (during the event).**

As always, use the **Pin** function to save the displays.

The next slides show the results.

2- Wildfire in Madrid (July 2019)



2019-06-27
(before the event)

2019-06-29
(during the event)

2- Wildfire in Madrid (July 2019)

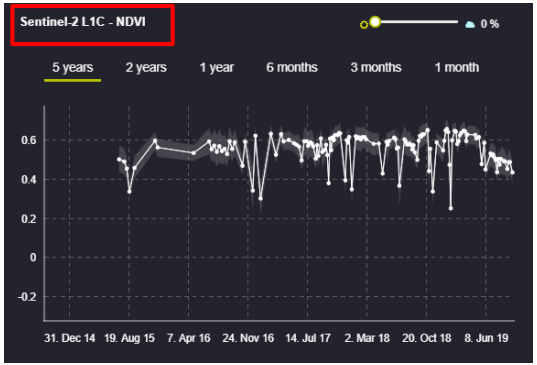
The next slide shows the **time series** of **Sentinel-2 L1C NDVI**, **Sentinel-2 L2A NDVI** and **Sentinel-2 Moisture Index**, for an area that was **burned** and for an area that remained **undamaged.**

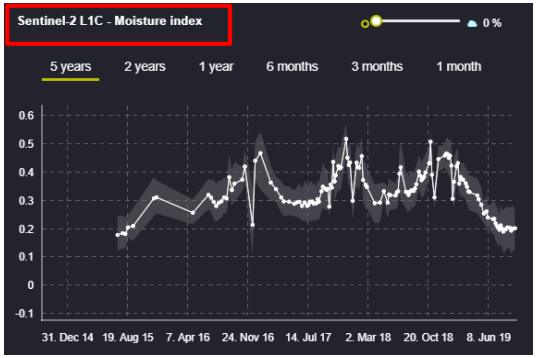
Ideally we would use only Sentinel-2 L2A, since this levels includes **atmospheric correction**. But in EO Browser, L2A time series have the drawback of being **shorter** than the L1C ones.

The reason for this is that ESA made the L2A products over Europe directly available from the Copernicus Open Access Hub only from May 2017. Note that Sentinel Hub (and consequently EO Browser) provide S2 L2A data for Europe since November 2016 and globally since December 2018. So within these limits, EO Browser can still show L2A products for areas and dates where ESA does not provide them.

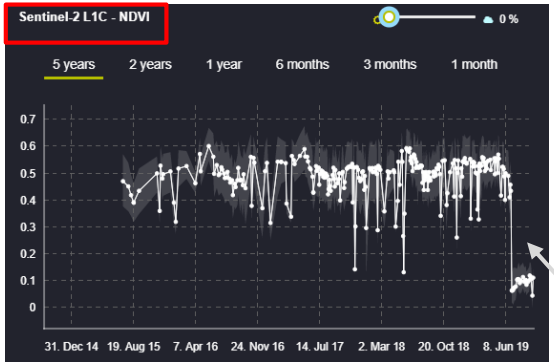
2- Wildfire in Madrid (July 2019)

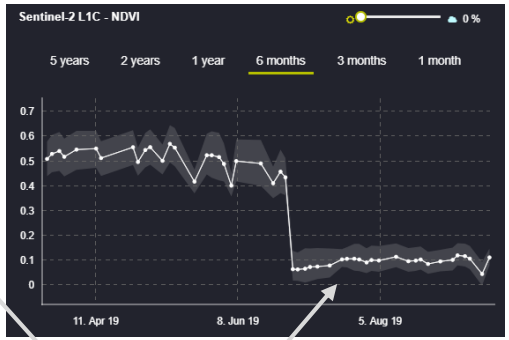
Unburned area (L1C)

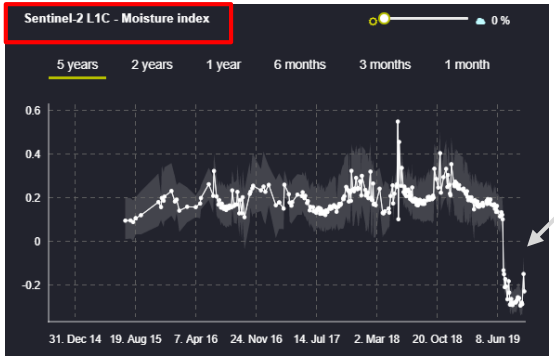




Burned area (L1C)



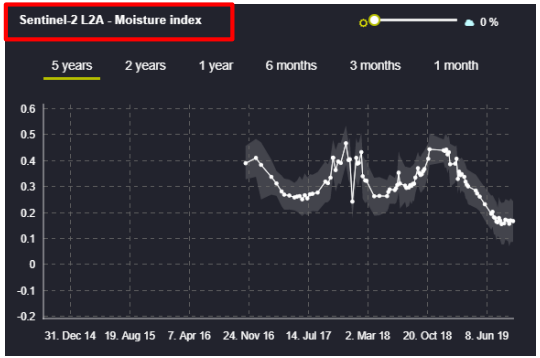




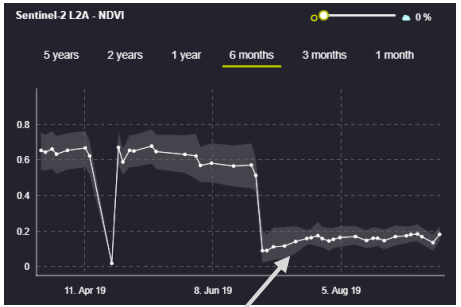
Fire caused a drop in the NDVI values

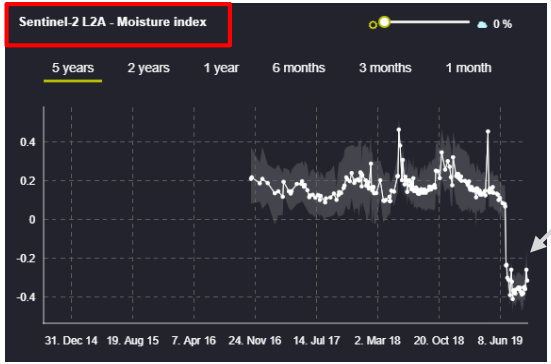
2- Wildfire in Madrid (July 2019)

Unburned area (L2A)



Burned area (L2A)





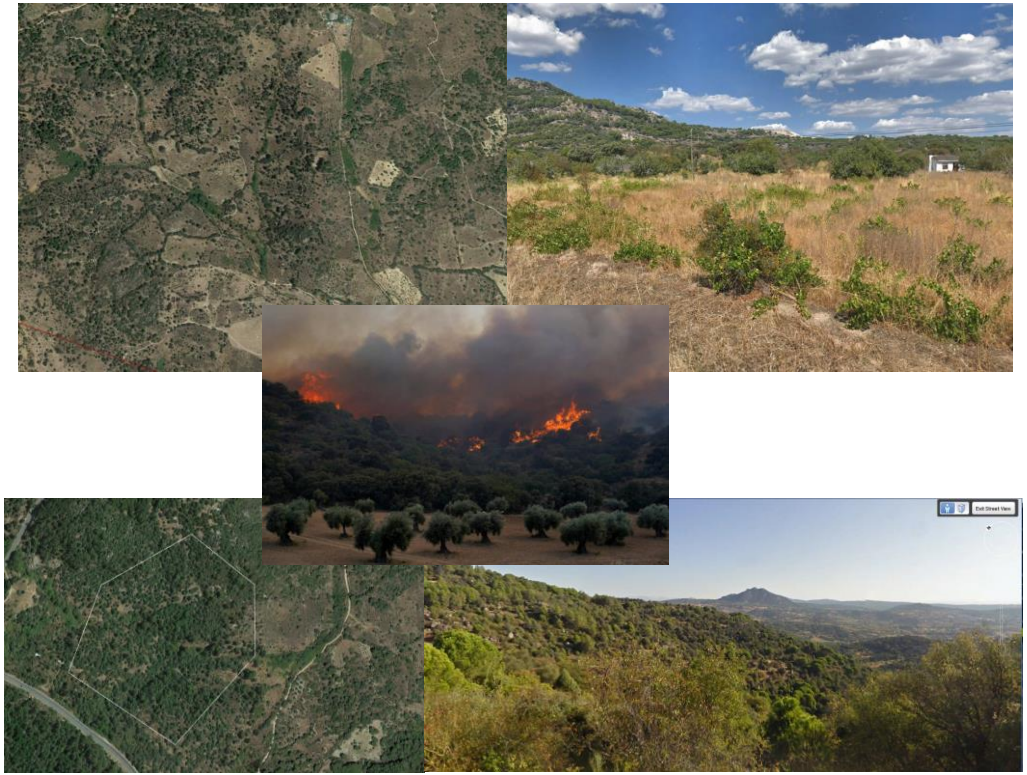
Fire caused a drop in the NDVI values

2- Wildfire in Madrid (July 2019)

To interpret SAR images correctly, it is important to have as much **information from the study area** as possible (land cover type, precipitation before the acquisition date of the image…).

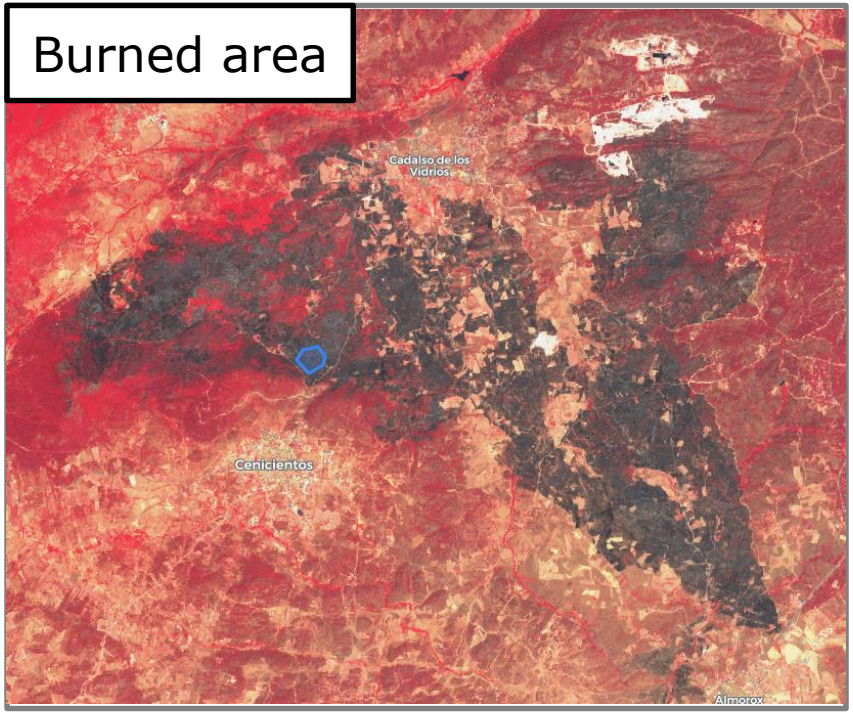
In the following slides we will see that **Sentinel-1 does not show clearly the burned scar in EO Browser**.

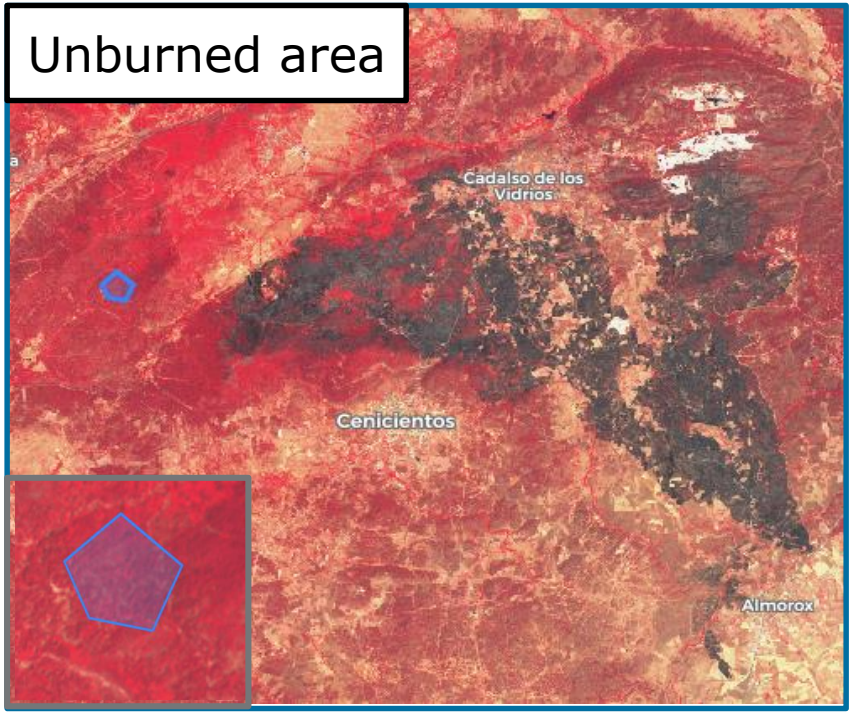
An important factor is the type of **land cover** in the region, with sparse trees and large areas covered by grass and shrubs.



2- Wildfire in Madrid (July 2019)

Below are **two subset areas**, taken from the **burned section** and from an **undisturbed area**. These polygons were manually drawn and they are displayed over the **False Colour** composite of the Sentinel-2 L2A image of **2019-07-01**.





2- Wildfire in Madrid (July 2019)

Next, search for **Sentinel-1** images **before** and **after** the event.
The next slides show the results for **VV[Db]–orthorectified** and for **VH[Db]–orthorectified.**

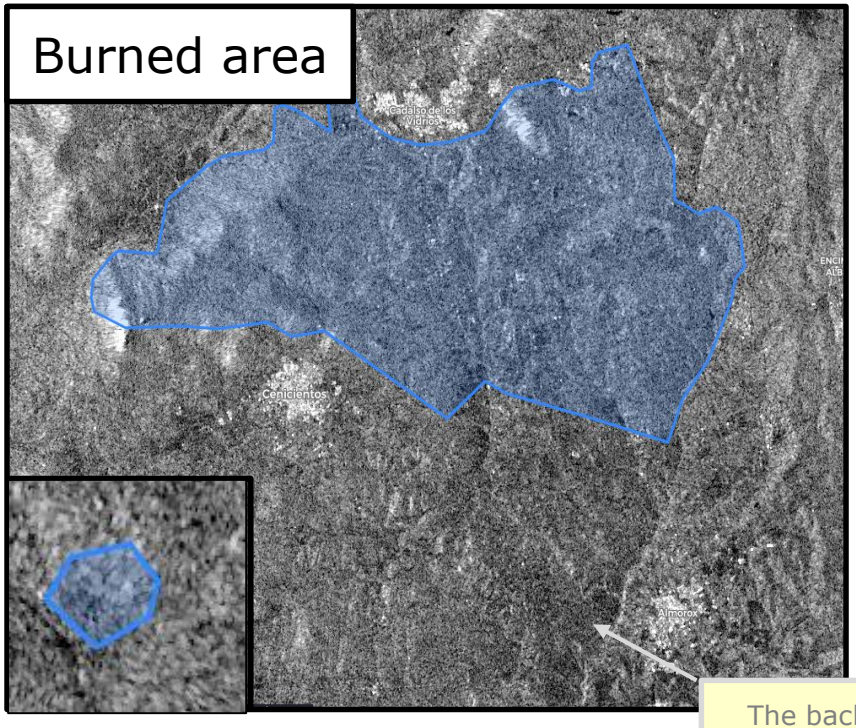
Notice that it is **not possible to see the pattern of the burned area** with this simple visualization.
Repeat for the **Unburned area**.

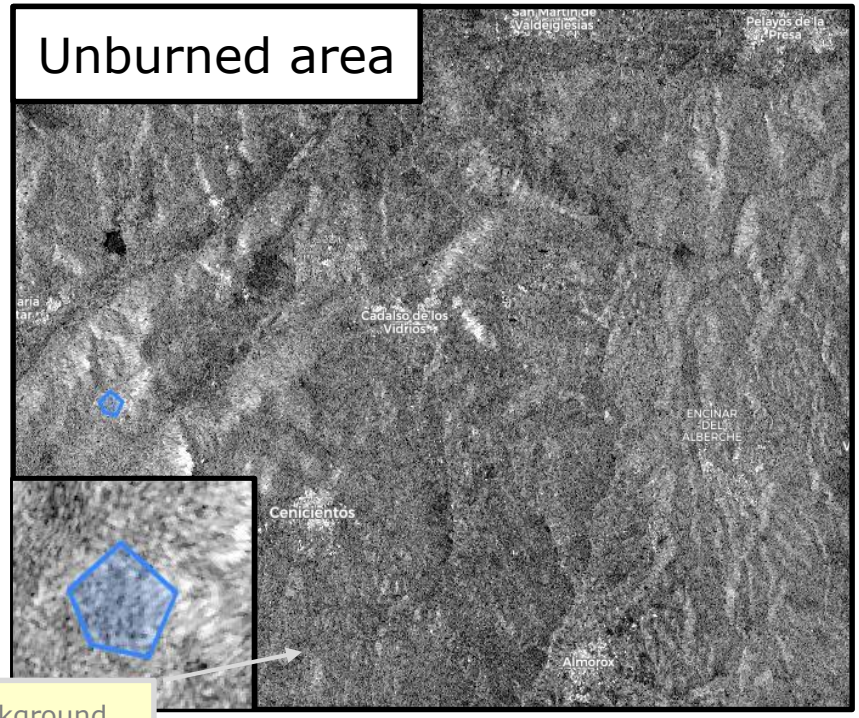
The results of this search are gathered in the following slides.

Note that Time Series tool is not available for Sentinel-1 in EO Browser, and that it is currently not possible to load several Areas of Interest. Therefore you need to carry out this comparison for each area (burned and unburned) separately.

2- Wildfire in Madrid (July 2019)

Results with **Sentinel-1 VV[Db]–orthorectified** from **2019-06-23 (before the fire)**

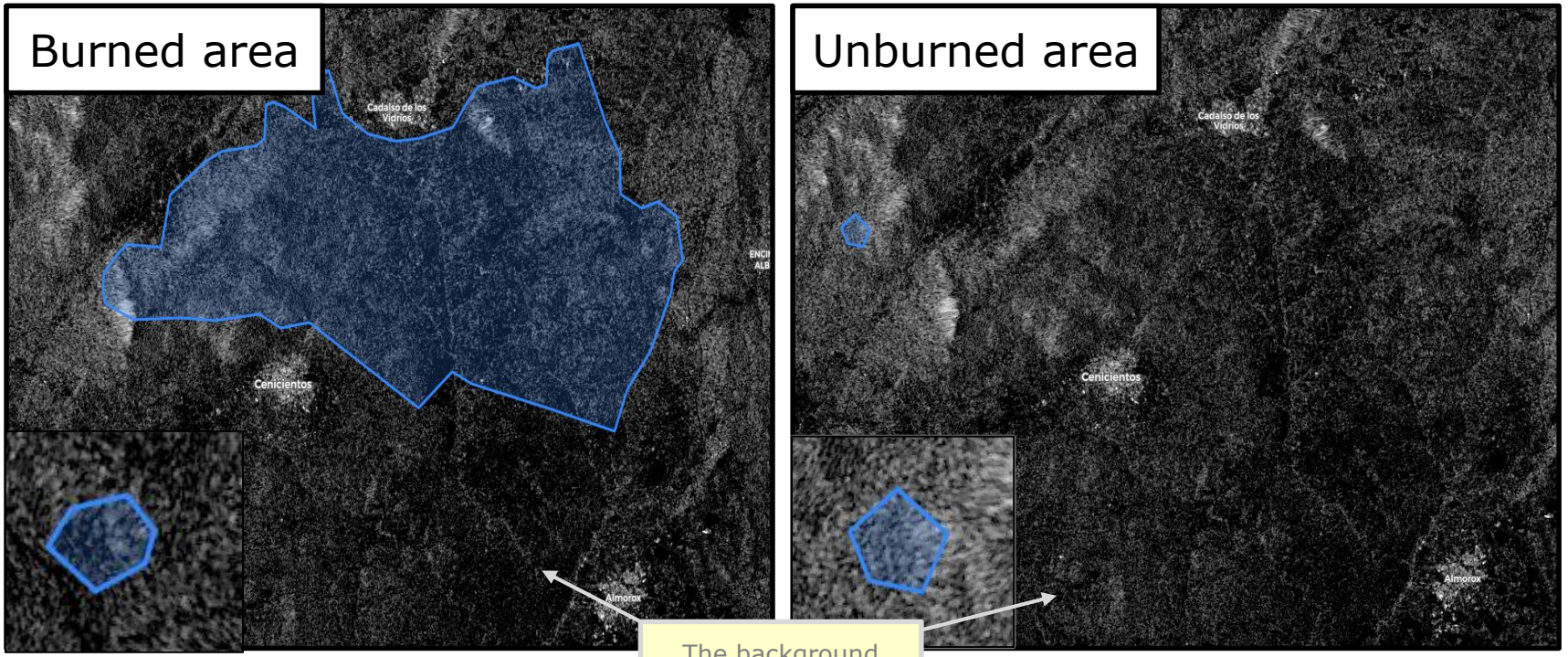




The background image is the same

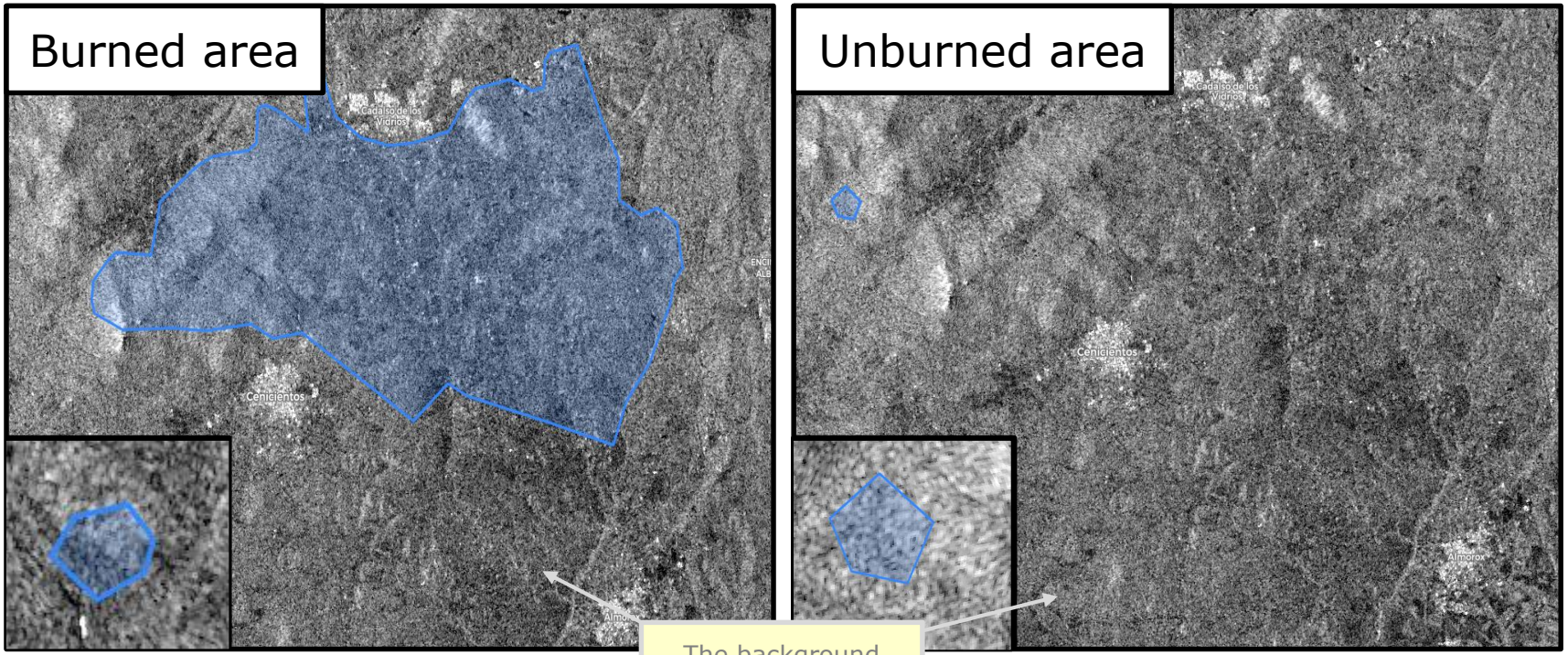
2- Wildfire in Madrid (July 2019)

Results with **Sentinel-1 VH[Db]–orthorectified** from **2019-06-23 (before the fire)**



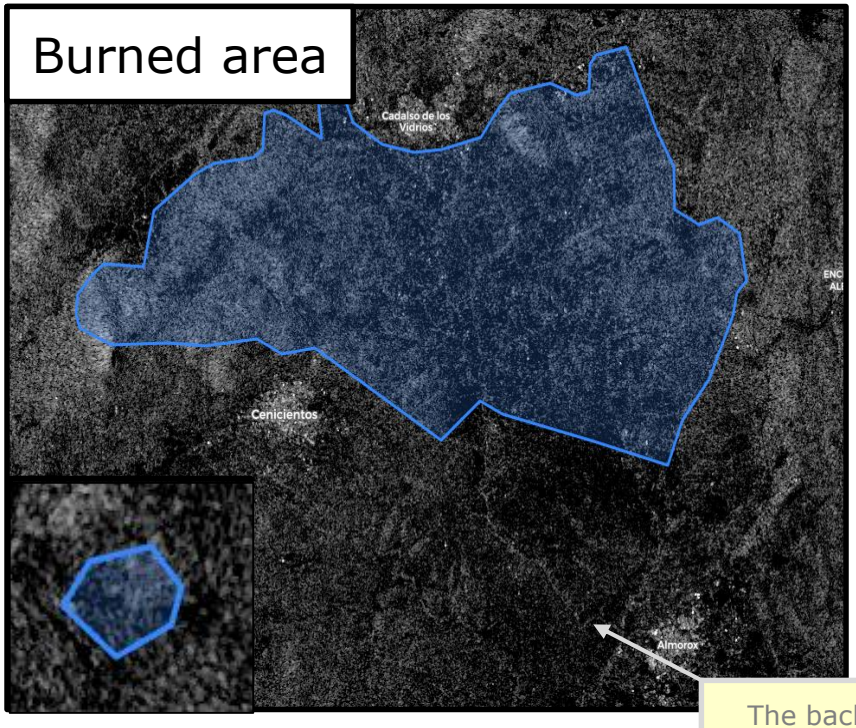
2- Wildfire in Madrid (July 2019)

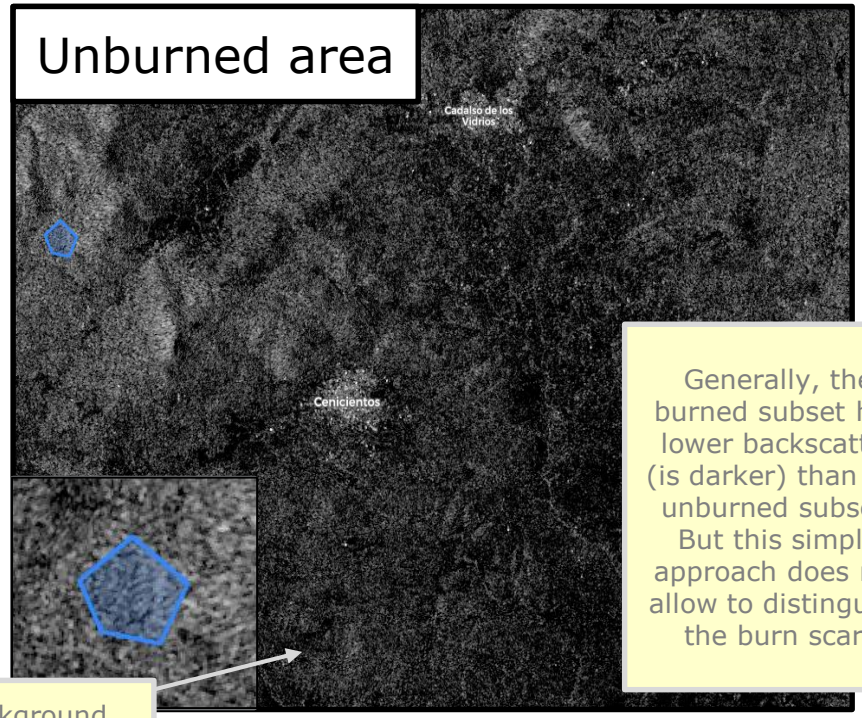
Results with **Sentinel-1 VV[Db]–orthorectified** from **2019-07-04 (after the fire)**



2- Wildfire in Madrid (July 2019)

Results with **Sentinel-1 VH[Db]–orthorectified** from **2019-07-04 (after the fire)**





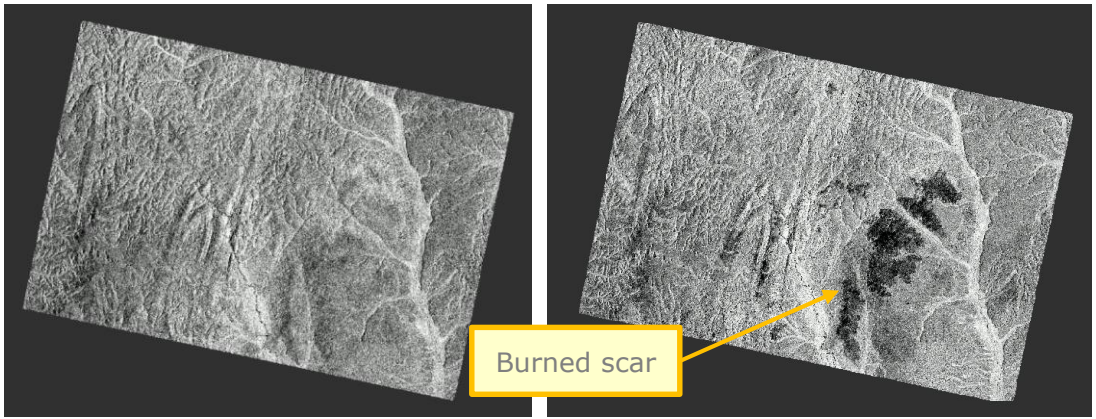
The background image is the same

Generally, the burned subset has lower backscatter (is darker) than the unburned subset. But this simple approach does not allow to distinguish the burn scar.

2- Wildfire in Madrid (July 2019)

Note: Depending on the event, S1 may be able to show the burned scar. See this example from another event, the 2016 wildfires in the Congo Basin.

Average backscatter for VV polarisation of S1 images (left: Average backscatter of images from November and December 2015; right: Average backscatter of images from January to April 2016).



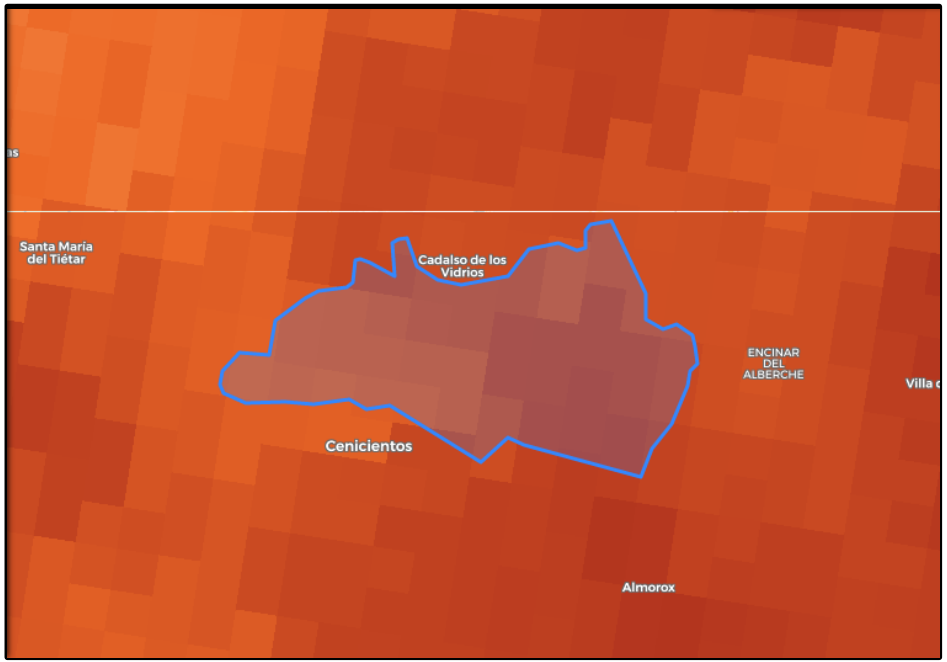
More info at the "Burned area mapping with S1 (SNAP)" exercise, accessible at https://eo4society.esa.int/resources/iv-esa-earsel-cnr-school-remote-sensing-for-forest-fires/

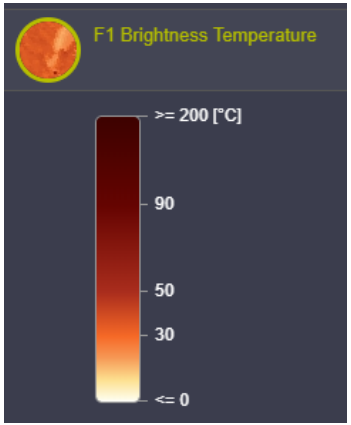
2- Wildfire in Madrid (July 2019)

Next we have a look at the area with **Sentinel-3**, in particular the **F1 Brightness Temperature** values, which **rise** coinciding with the wildfire.

2- Wildfire in Madrid (July 2019)

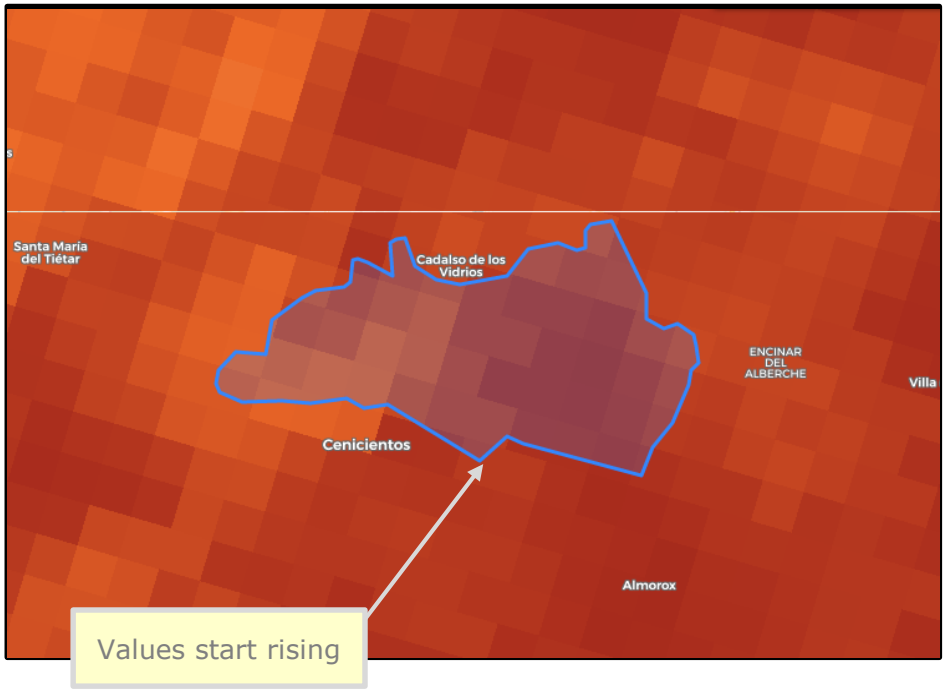
Results with **Sentinel-3 F1 Brightness Temperature** from **2019-06-26 (before the fire)**

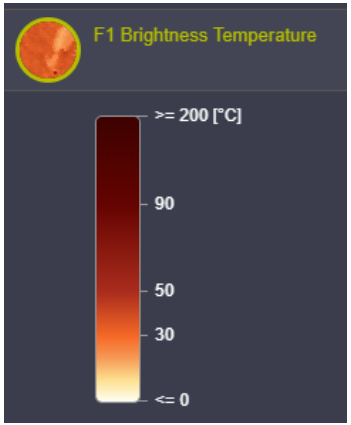




2- Wildfire in Madrid (July 2019)

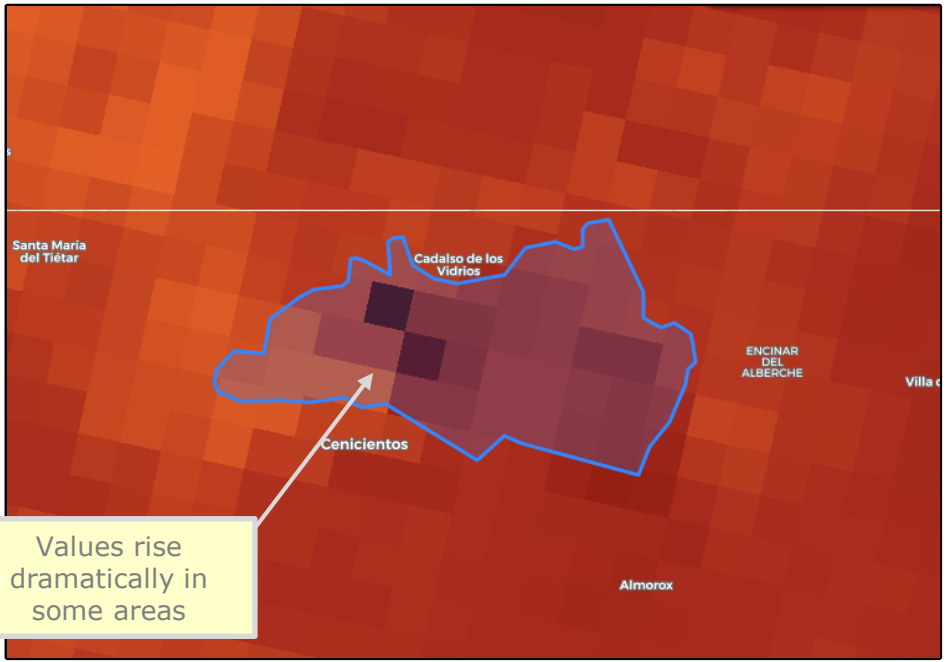
Results with **Sentinel-3 F1 Brightness Temperature** from **2019-06-28 (during the fire)**

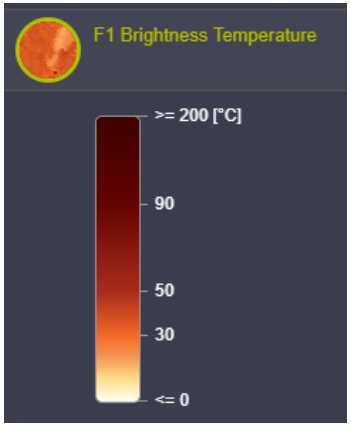




2- Wildfire in Madrid (July 2019)

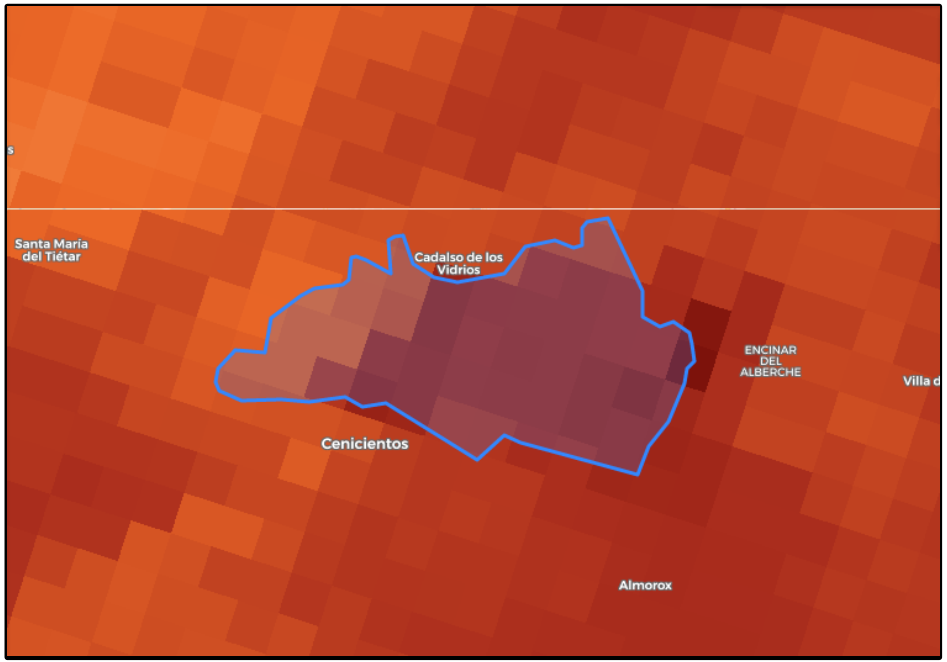
Results with **Sentinel-3 F1 Brightness Temperature** from **2019-06-29 (during the fire)**

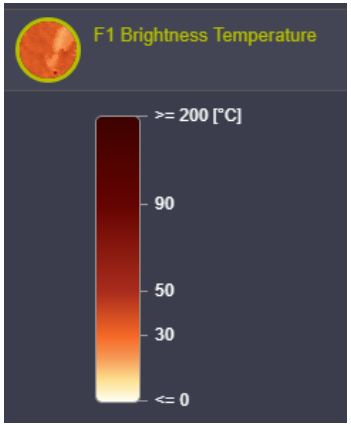




2- Wildfire in Madrid (July 2019)

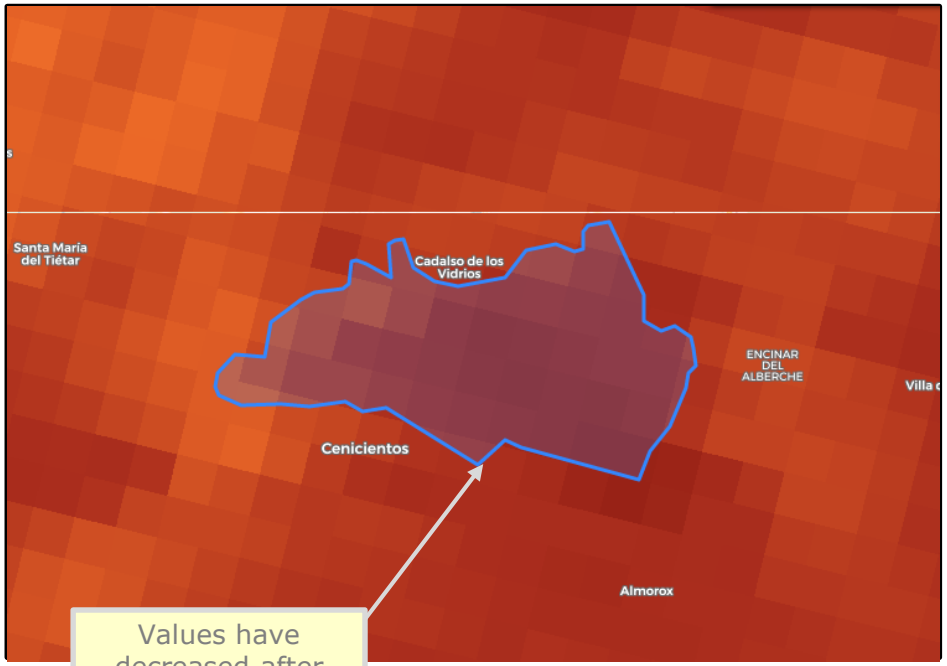
Results with **Sentinel-3 F1 Brightness Temperature** from **2019-06-30 (during the fire)**

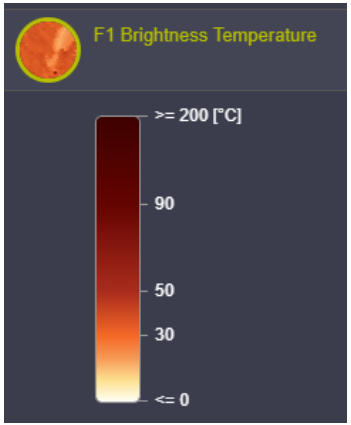




2- Wildfire in Madrid (July 2019)

Results with **Sentinel-3 F1 Brightness Temperature** from **2019-07-01 (after the fire)**





Learning goals

- ✓ Understand the negative and beneficial consequences of wildfires and how satellite imagery can be employed (Wildfires Case Study)
- ✓ Be introduced to the Normalised Burn Ratio (NBR) and to the Normalized Difference Vegetation Index (NDVI)
- ✓ Be introduced to the use of Themes in EO Browser
- ✓ Compare different images or products in EO Browser
- ✓ Be introduced to the use of custom scripts in EO Browser (with additional info on extending custom scripts, using URL and storing scripts)
- ✓ Learn how to upload/digitize polygons and obtain the extent of an area in EO Browser
- ✓ Display and interpret Sentinel-2 NDVI (L1C and L2A) time series in EO Browser
- ✓ Display and interpret Sentinel-5P CO and NO2 maps in EO Browser
- ✓ Create a timelapse in EO Browser
- ✓ Display and interpret Sentinel-2 Moisture Index maps in EO Browser
- ✓ Be introduced to the challenges of using Sentinel-1 for fire scar mapping
- ✓ Display and interpret Sentinel-3 F1 Brightness Temperature maps in EO Browser

Thank you for your attention!

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