



## EXERCISE 8 – TUTORIAL

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Mapping wildfires and burn severity using Sentinel-2 data, using SNAP software

# 1 | Exercise outline

In this exercise, we will:

- Detect wildfires on Sentinel-2 image
- Export subset as image to perform another analysis in QGIS
- Map burned areas and quantify burn severity using Normalised Burn Ratio index
- Develop a graph for automated processing using Batch processing

## 2 | Background

Fires in the grasslands close to a vital South American river delta present serious threats to both nearby wetland ecosystems and human well-being, caution environmental experts.



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The Parana River, South America's second-longest river after the Amazon, experienced its lowest water levels since 1944 in 2021 as reported by official data. This decline is attributed to multiple cycles of drought and reduced rainfall in upstream Brazil. In August 2022, the water level remained exceptionally low. The wildfires, many intentionally set by farmers preparing the land for new crops, generated a thick haze that reached Buenos Aires, located approximately 190 miles (300 km) south of Rosario. Residents were displeased with the presence of soot in the air, leading popular weather apps to issue forecasts simply describing the conditions as "smoke."



Wildfires burning in the wetlands of the Paraná River Delta, Argentina, 19 August, 2022

## 2.1 Study area and data used

For this exercise, we will use two Sentinel-2 images of the same area in Paraná River Delta, Argentina, using the Tile Number \*20HQJ\* downloaded for two days of summer 2022 (before and after the wildfires) from the Dataspace Copernicus Open Access Hub [[@https://dataspace.copernicus.eu/](https://dataspace.copernicus.eu/)].

## 2.2. SNAP - Open and explore product

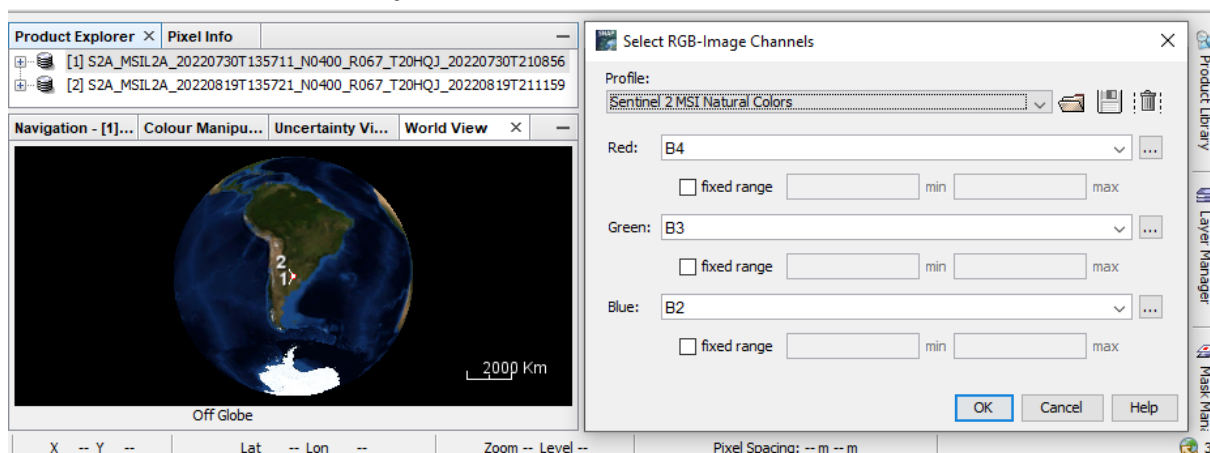
Open SNAP Desktop, click Open Product and open 2 downloaded products (unzipped) by double click on the metadata „MTD\_MSIL2A.xml“ inside the folder. The opened products will appear in Product Explorer window.

S2A\_MSIL2A\_20220730T135711\_N0400\_R067\_T20HQJ\_20220730T210856.SAFE.zip

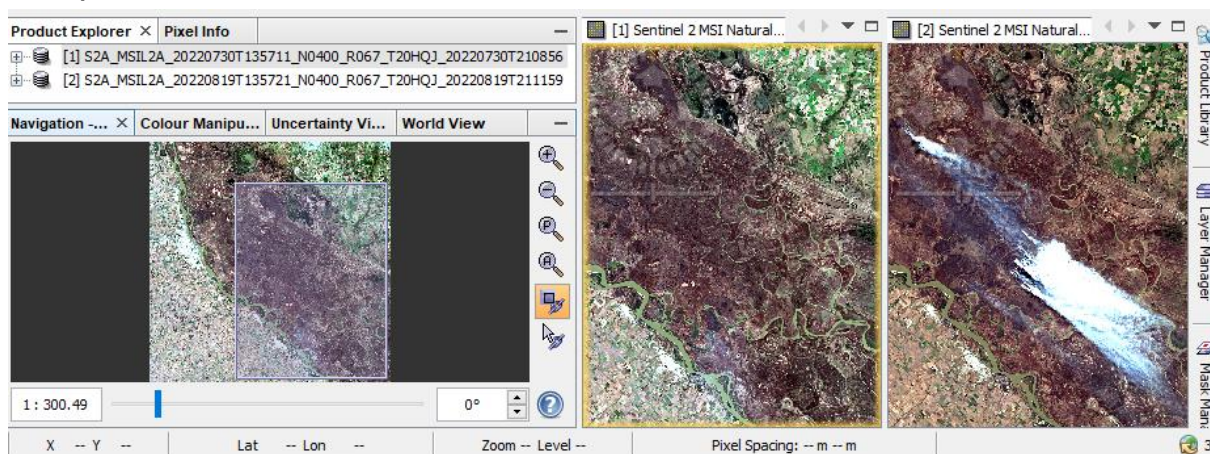
S2A\_MSIL2A\_20220819T135721\_N0400\_R067\_T20HQJ\_20220819T211159.SAFE.zip

### A: Detecting wildfires on Sentinel-2 image

1. Select the first product in the Product Explorer window.
2. Right click on the product.
3. Open RGB Image Window.
4. In the pop-up window select 'Sentinel 2 MSI Natural colors (Red: B4; Green: B3; Blue: B2)'.

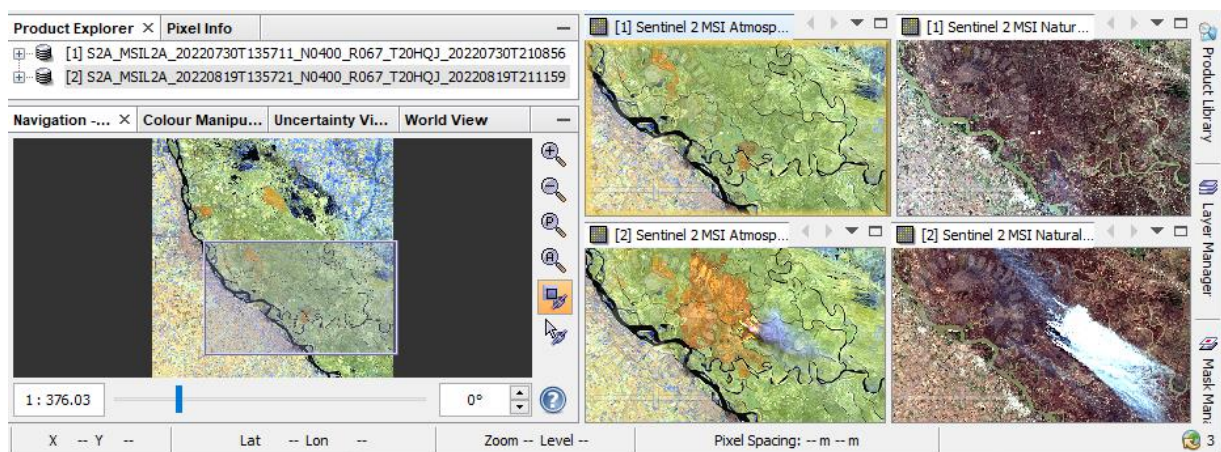


5. Repeat the process for the second product.
6. Tile two opened RGB Windows, e.g. horizontally
7. In the Navigation window, zoom in to the wildfire region and synchronise views to see the same area before and after wildfires



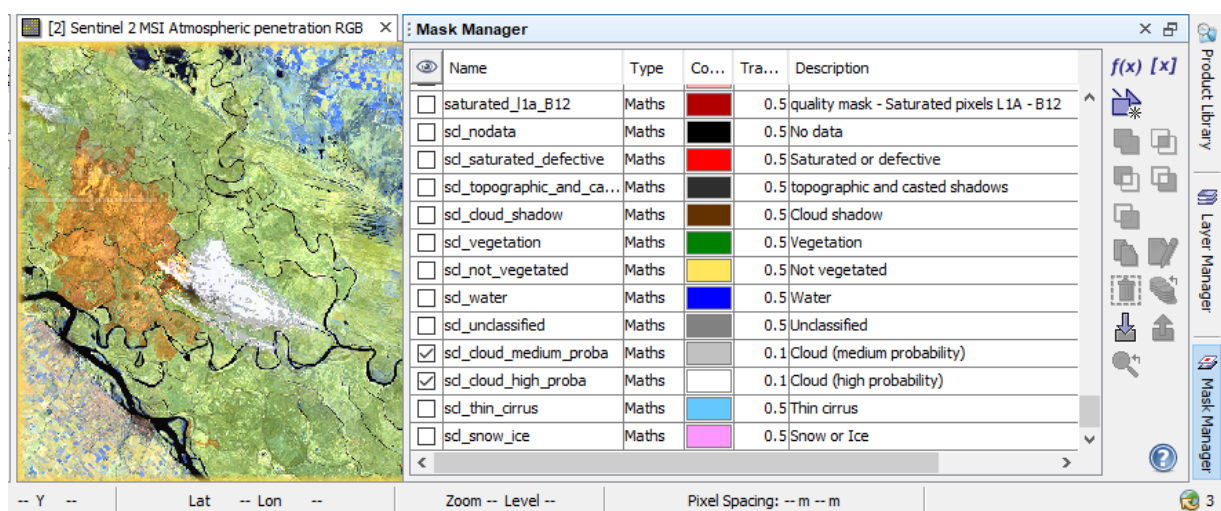
Do the same process for obtaining the color composition in false colors:

1. Select the first product in the Product Explorer window.
2. Right click on the product.
3. Open RGB Image Window.
4. In the pop-up window select 'Sentinel 2 MSI Atmospheric penetration (Red: B12; Green: B11; Blue: B8A)'.
5. Apply color manipulation (stretching) for RGB
6. Repeat the process for the second product.
7. Tile opened RGB Windows, e.g. evenly
8. If necessary, in the Navigation window, zoom in again to the wildfire region and synchronise views to see area before and after wildfires



Now let's detect the smoke plume:

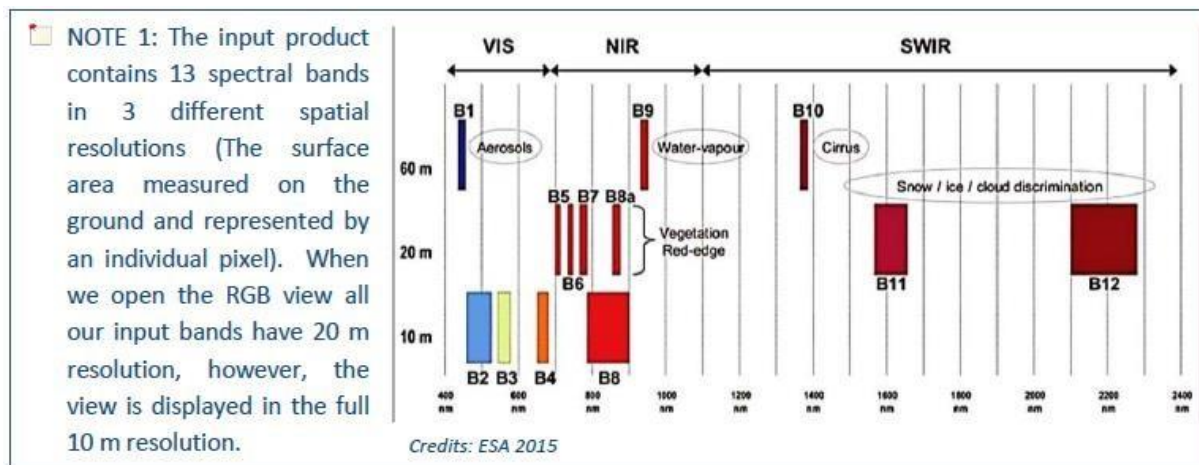
1. Keep only the Sentinel 2 MSI Atmospheric penetration composition with visible smoke plume from 19 August open
2. Go to Mask Manager, and scroll down to the Maths masks
3. Select: "scl\_cloud\_medium\_proba" and "scl\_cloud\_high\_proba"
4. To visualize the masked areas better, lower the transparency(e.g. 0.1)



Fire + cloud plume map

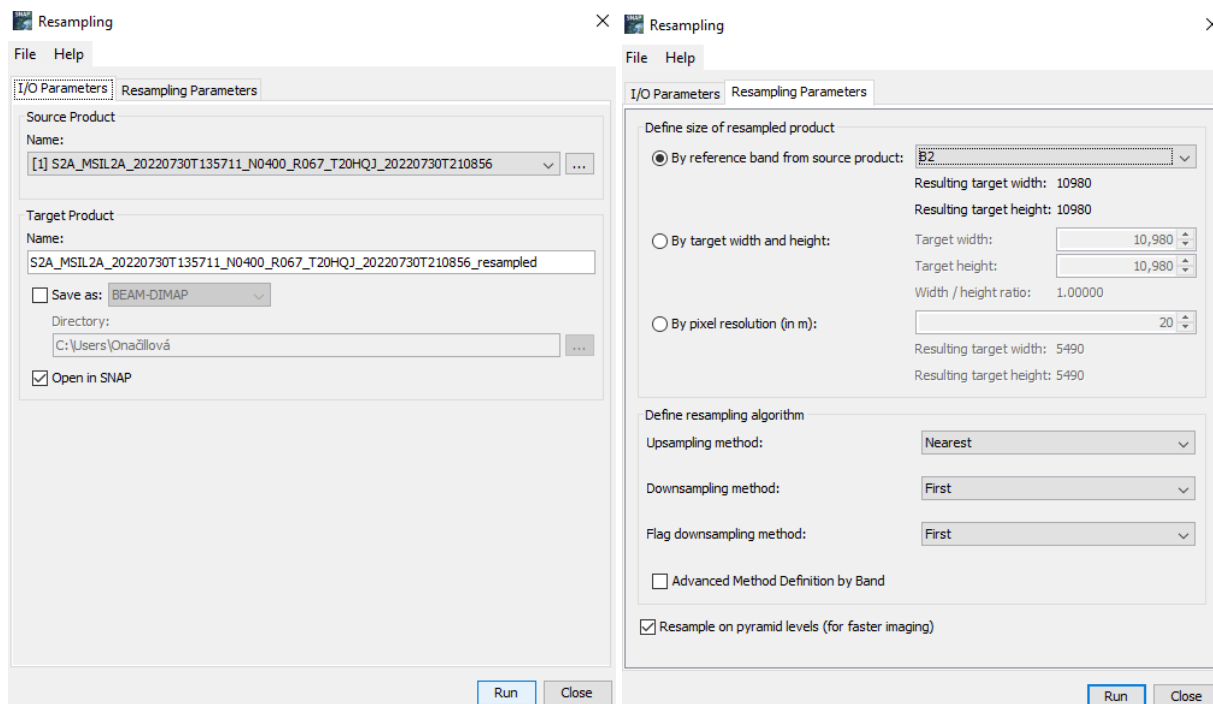
## Let's export this View as an image and save as a GeoTIFF:

Because of multiple S2 spatial sizes, we first have to resample the data. Resample to highest spatial resolution: 10 m (e.g. B2).



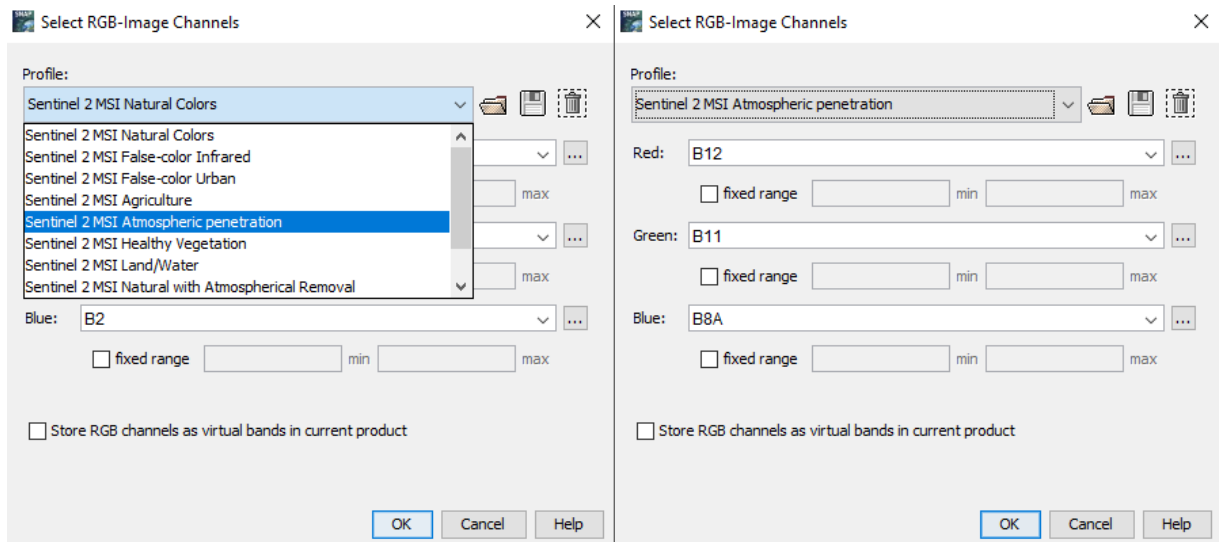
## Raster->Geometric->Resampling:

- Keep I/O names
- In Resampling Parameters, select B2 (10 m)

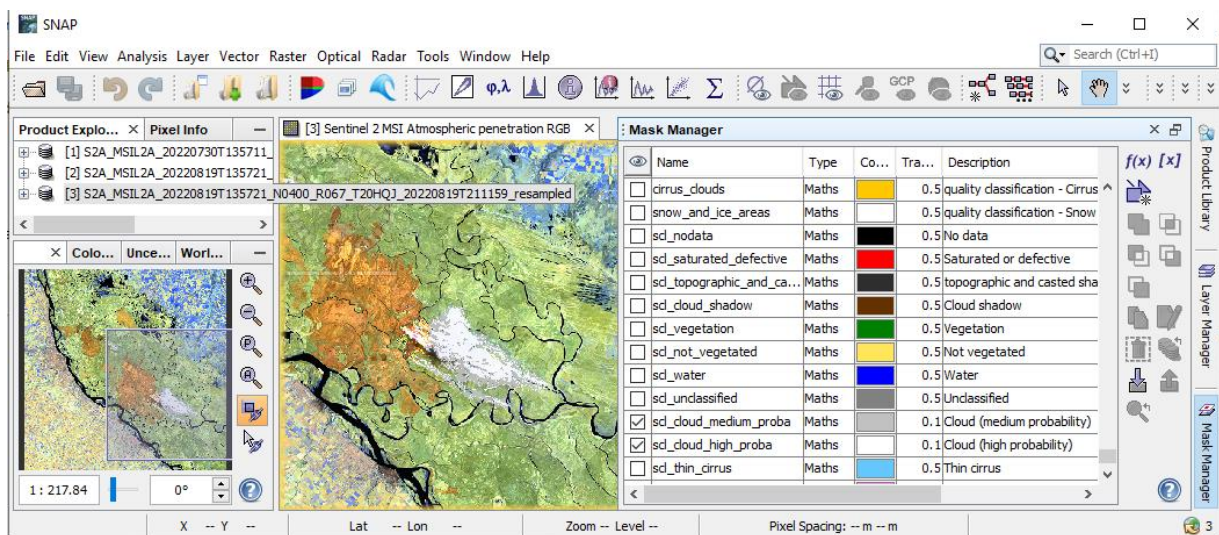


## Let's create a subset based on the current view

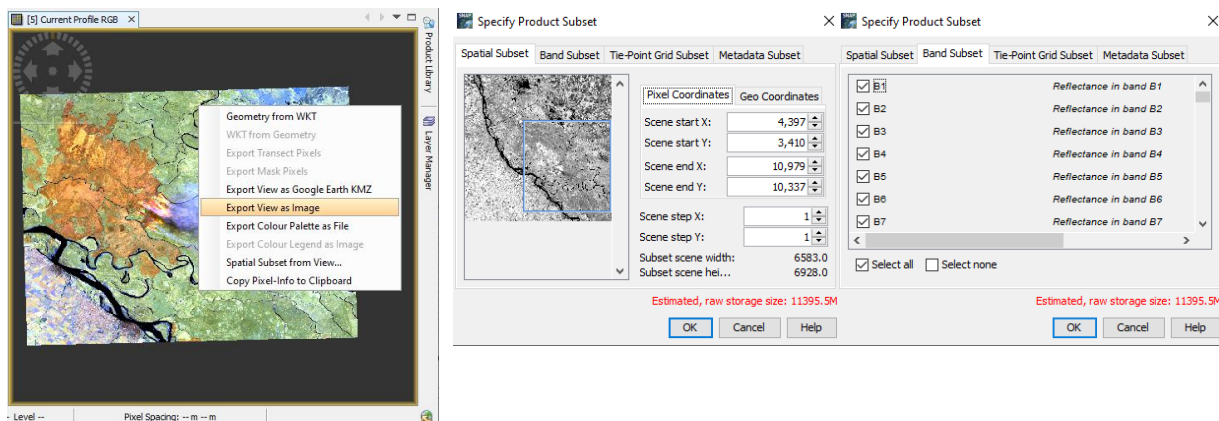
- Display the image. Note that now many more color options are available. Select MSI Atmospheric penetration



- Make a zoom and add the cloud masks again

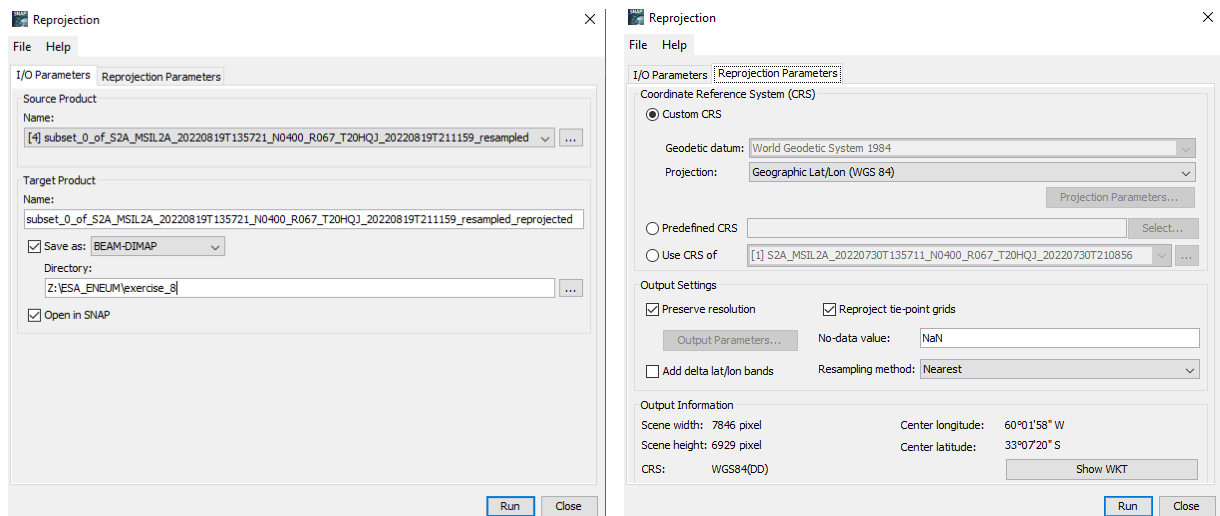


- Right-mouse button -> Spatial Subset from View – in the Band Subset you can select all or only few bands to be exported



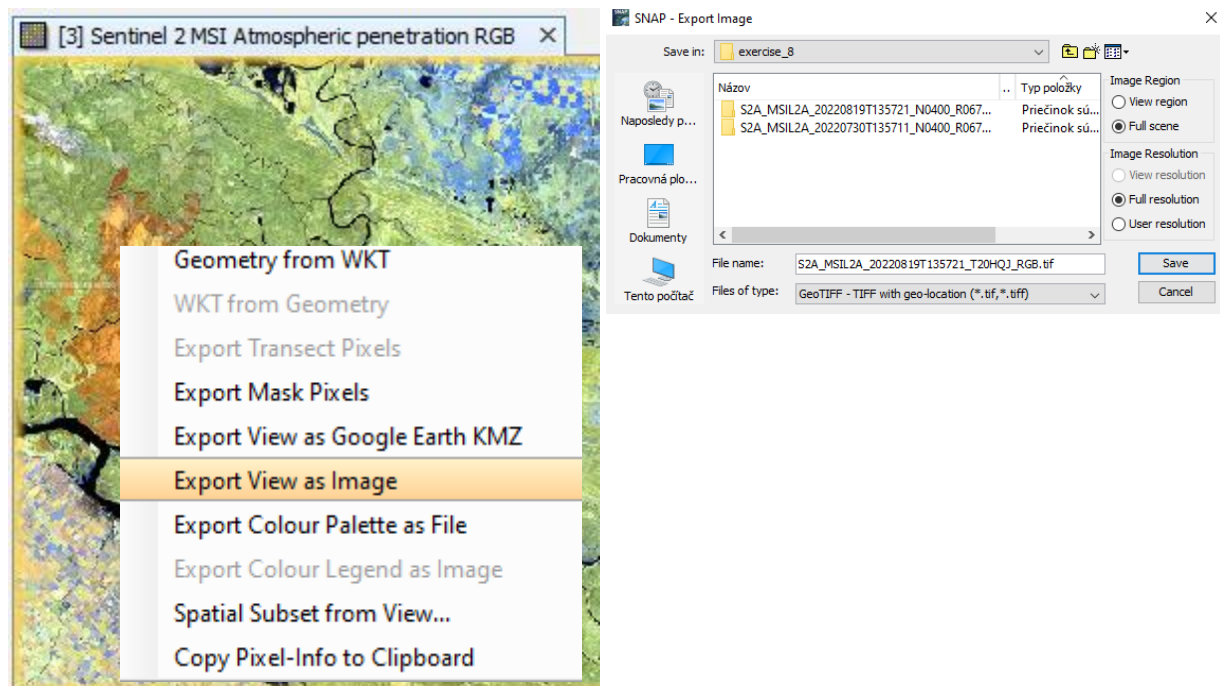
## Let's reproject the image in Latitude & Longitude coordinates

- Raster->Geometric Operations->Reprojection
- Select the default: Geographic Lat/Lon (WGS 84)
- Run (writing might take some time)



## Now we can export View as GeoTiff

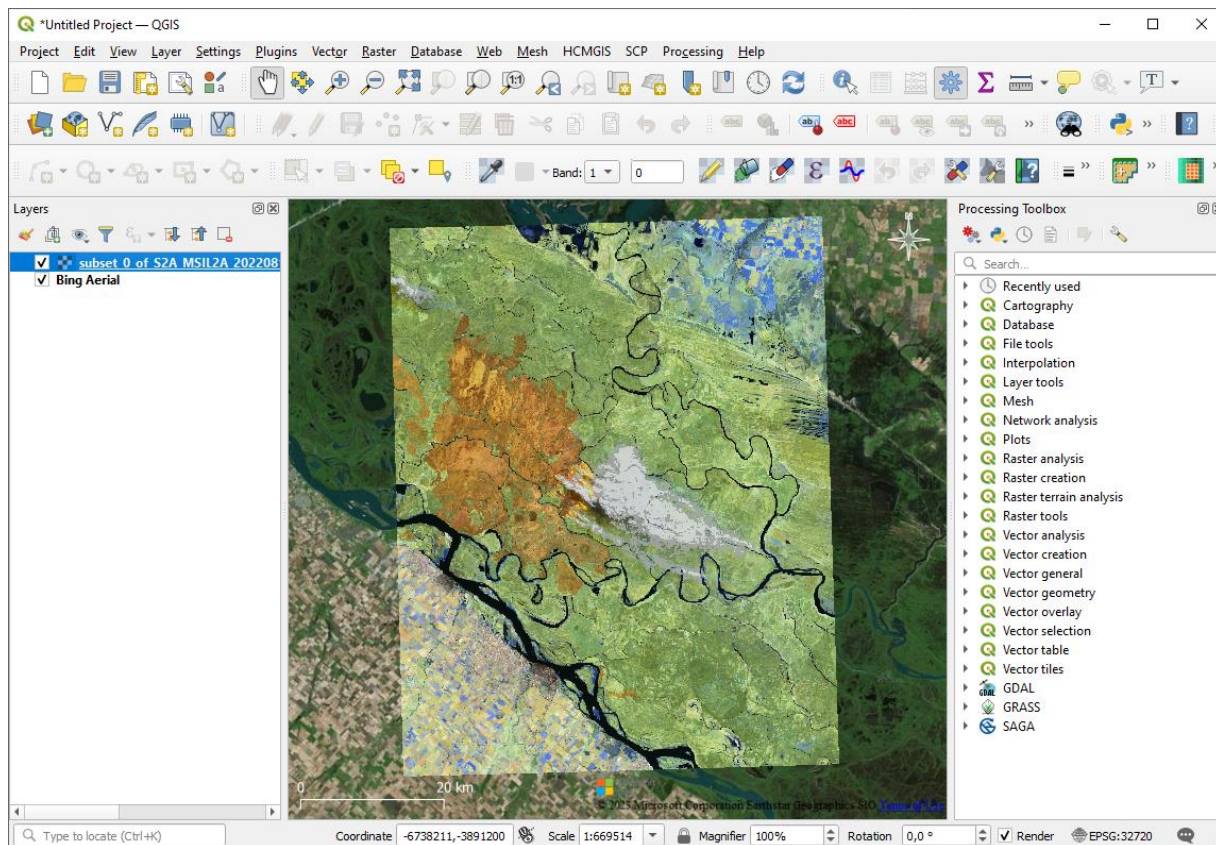
- Right mouse button: Export View as Image
- Select: Full scene, Full resolution, GeoTIFF





## Now we open the output image in QGIS

- We can overlay it to e.g. Google Satellite or Bing aerial image:
- Web->OpenLayers plugin->Google Maps->Google Satellite
- Move the Subset above the satellite
- Play with Transparency: Properties->Transparency (e.g. 80%)

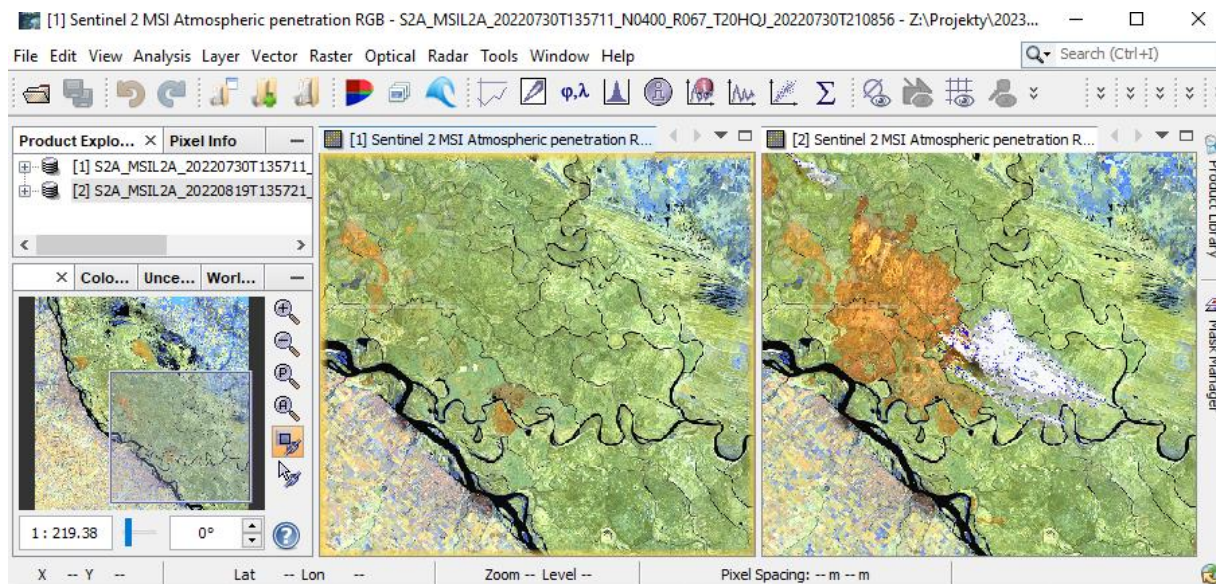


## B: Burned area mapping with Sentinel-2

How to quantify the impact of the Paraná wildfire?

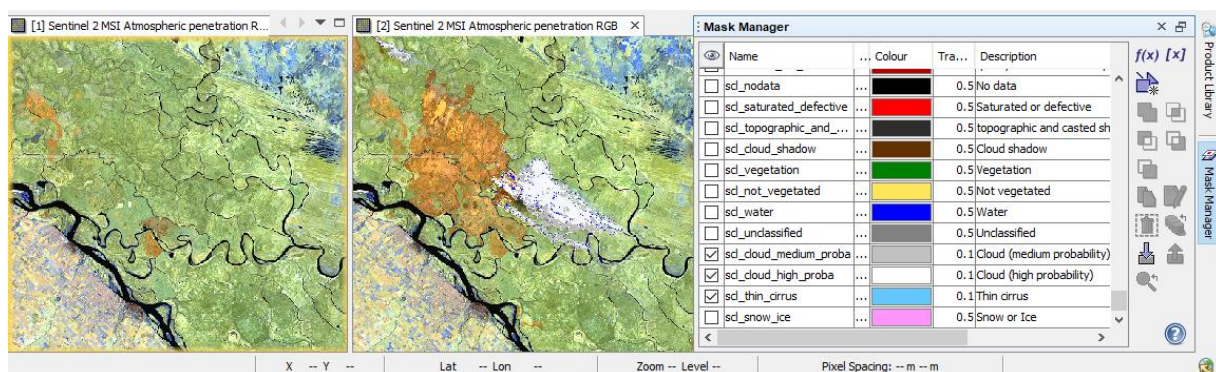
### Let's have look to the before & after images:

- Open RGB Image Window:
- Select: MSI Atmospheric penetration
- Window-> Tile horizontally, zoom in



### Let's create a cloud mask:

- Go to Mask Manager, and scroll down to the Maths masks
- Select: cloud medium & cloud high probability & Thin cirrus
- To visualize them better, lower the transparency (e.g. 0.1)

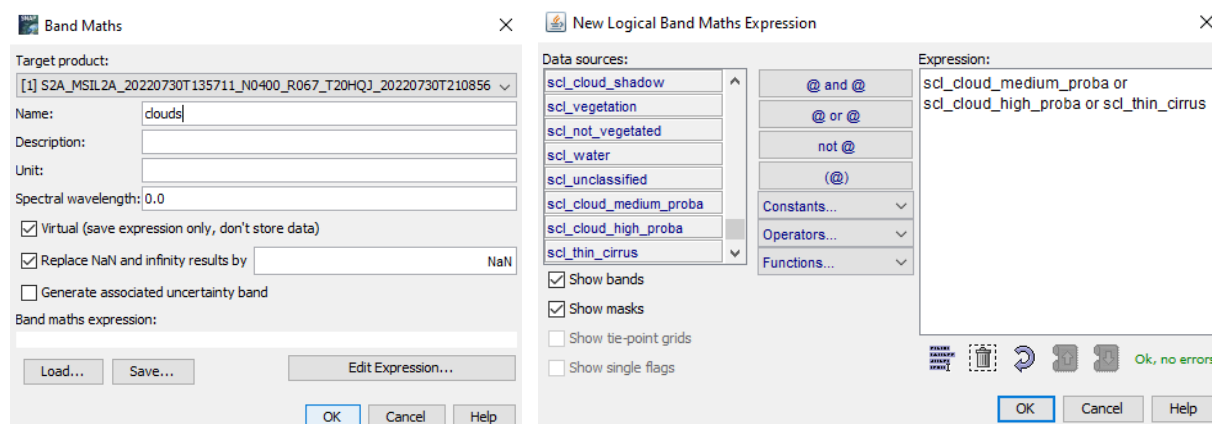


Now we make a cloud band based on the selected mask

- Band math expression

## We make a cloud band based on the selected mask

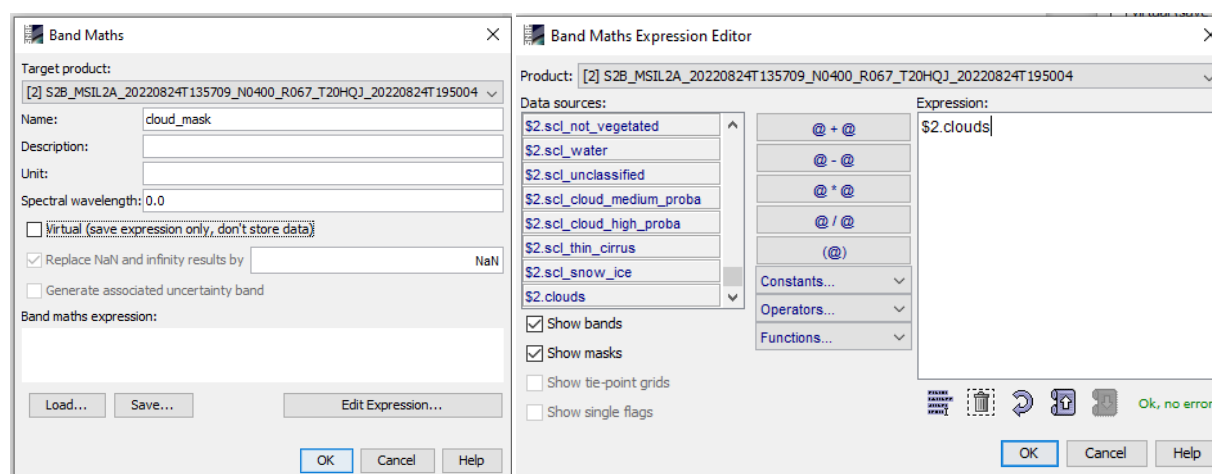
- Navigate to Raster - Band Maths
- Name the new mask: **clouds**



## Adding the cloud mask as a band

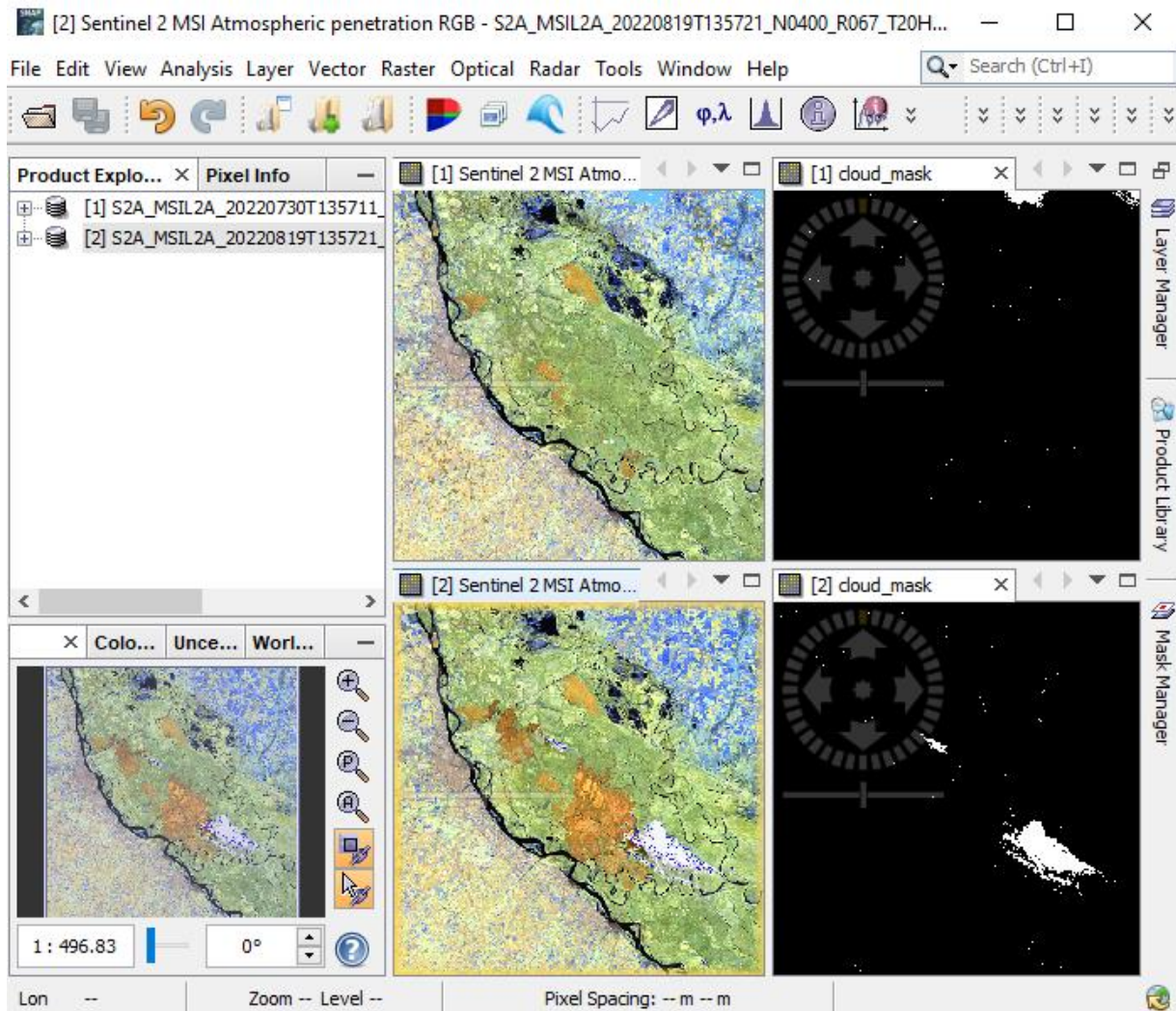
- On the image, right click-> Band Maths
- Make sure to deactivate "Virtual". We want to store the data!
- Go to "Edit Expression"
- Select Clouds

Repeat for the second image

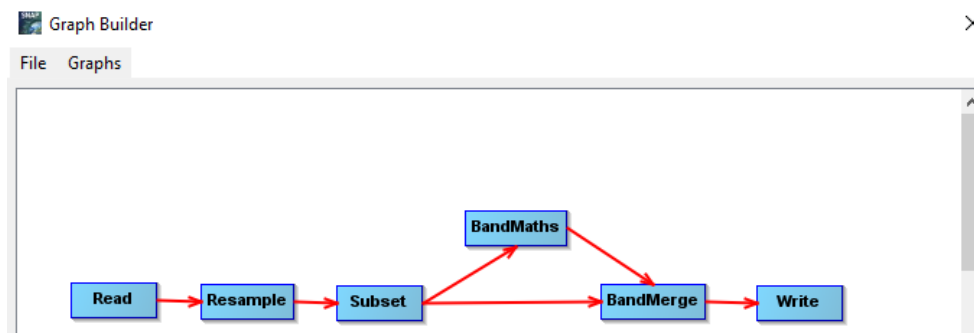


## Vizualize all products

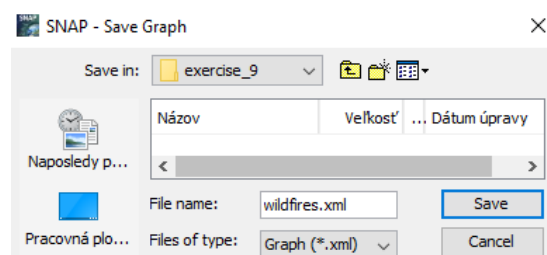
- Windows: Tile evenly
- Navigation: zoom all



## Tools – Graph Builder



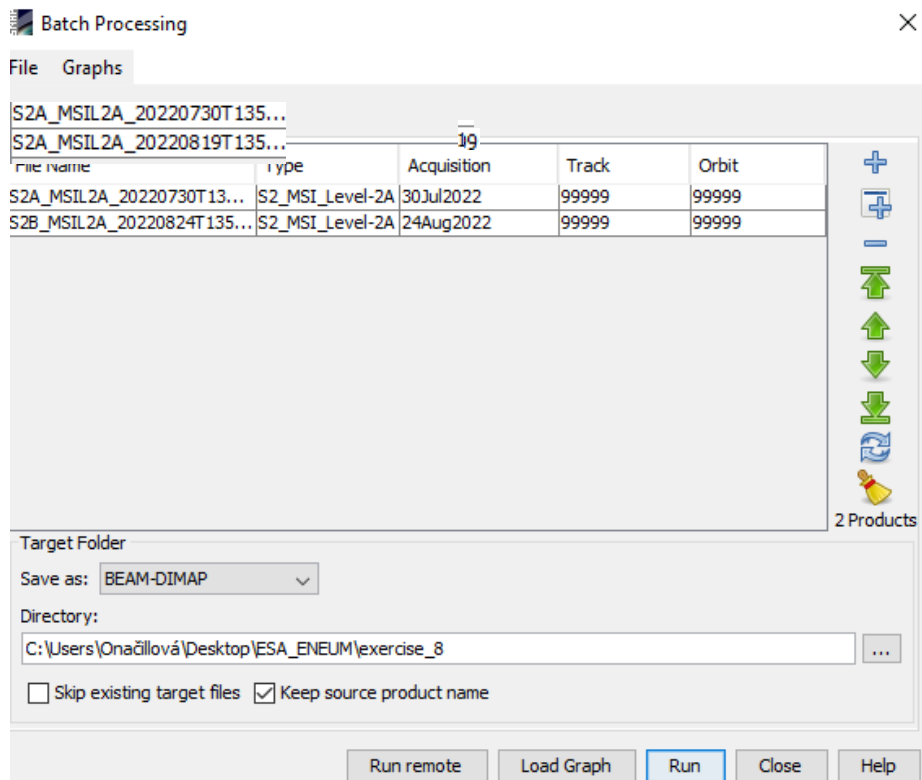
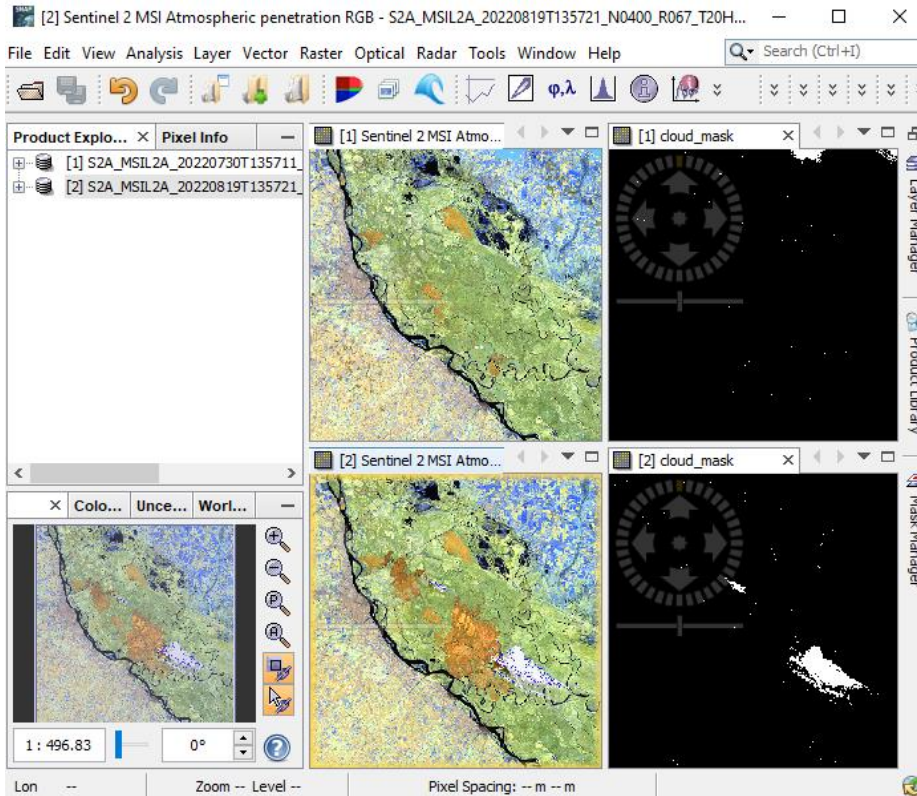
- Add->Raster->Geometric->Resample
- Add->Raster->Geometric->Subset
- Add->Raster->BandMaths
- Add->Raster->BandMerge
- Save your created graph



## Tools – Batch processing

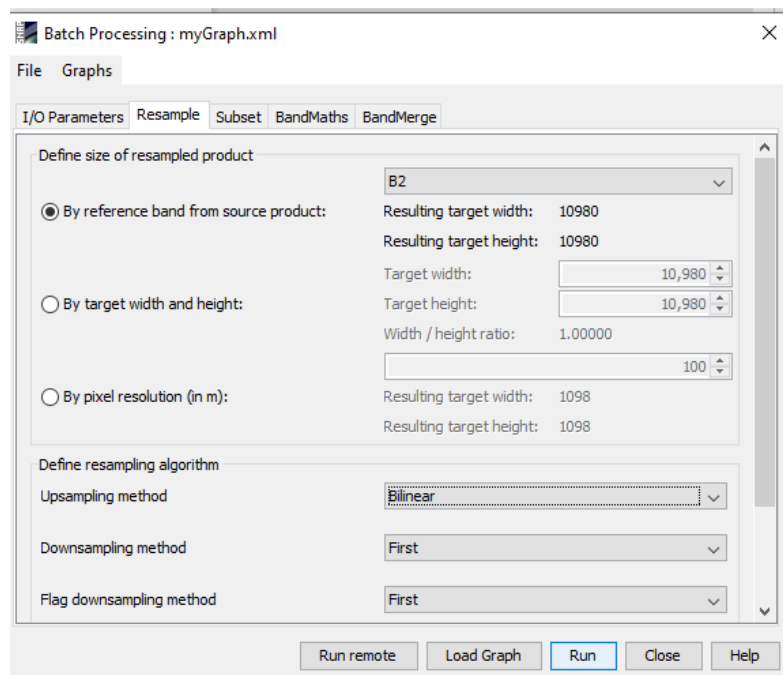
This allows to process both images at the same time.

- Click on Add opened
- Load your graph
- Make sure to refresh



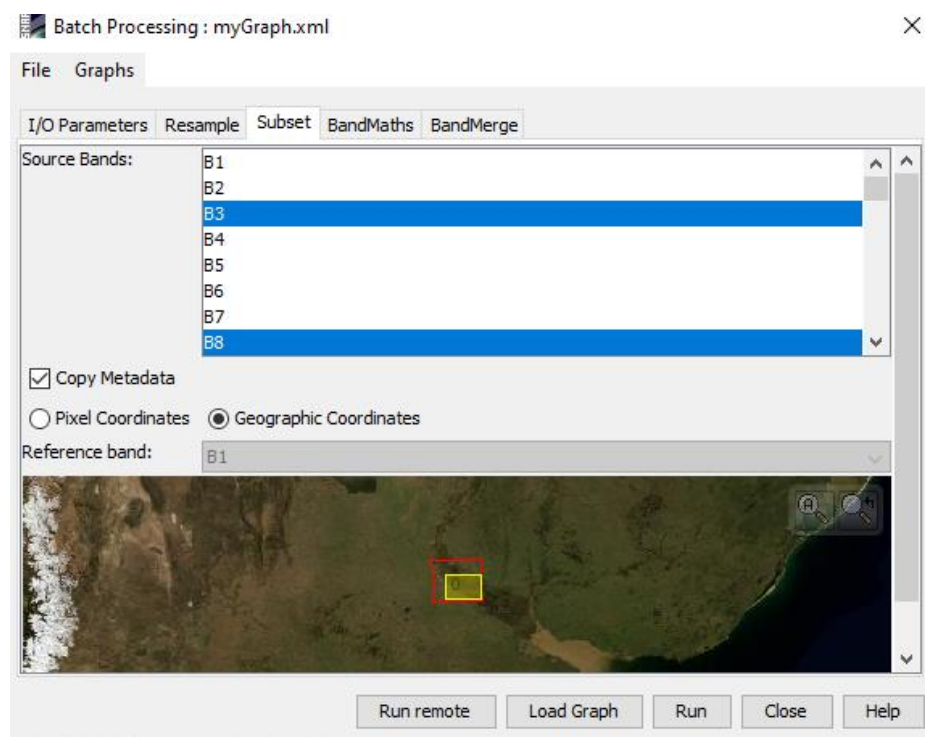
## Resample

- Select a reference band: B2 at 10 m.
- Resampling method: Bilinear



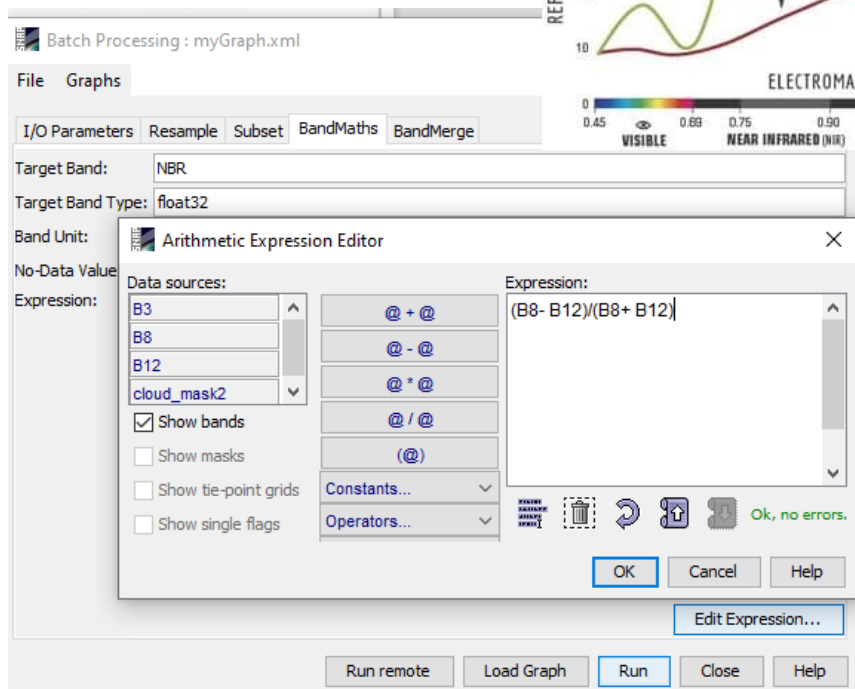
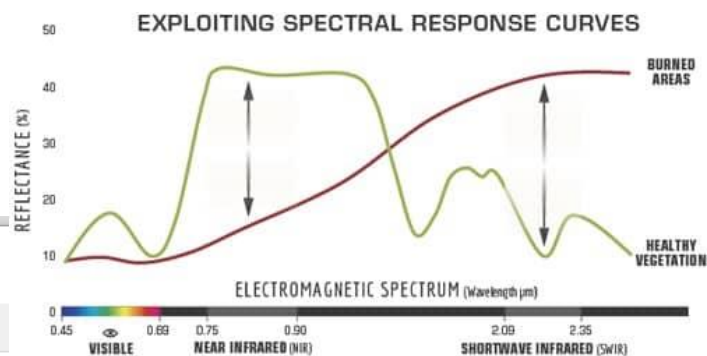
## Subset

- Select bands: B3, B8, B12, Cloud\_mask
- Select Geographic coordination
- Click on A, zoom in to the area of interest
- Select a yellow box within the red square



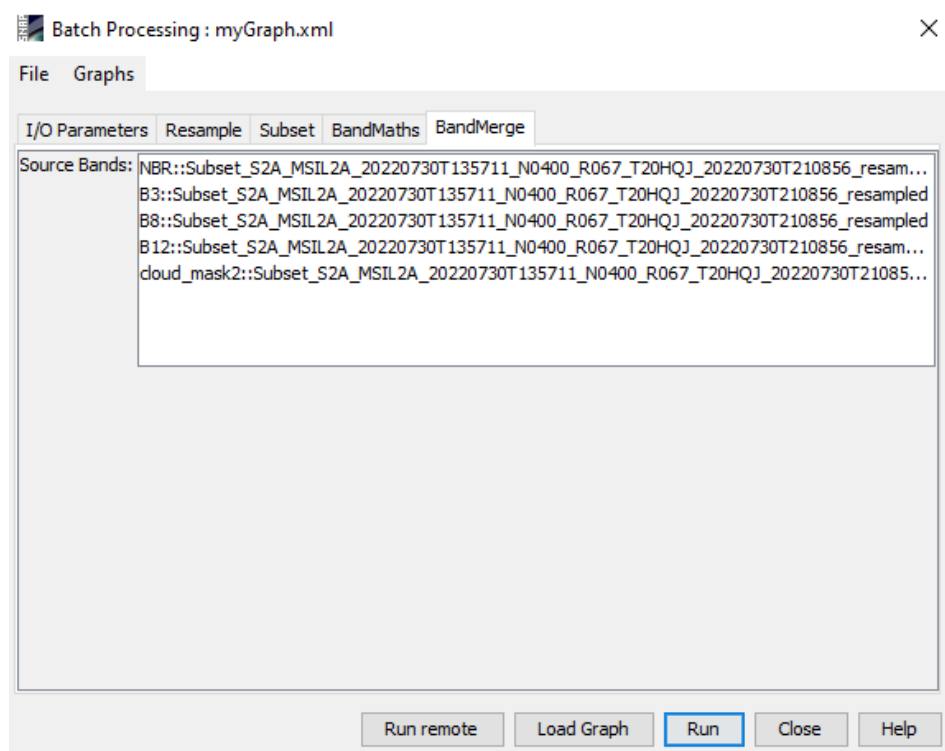
## Band Math

- Go to "Edit Expression"
- NBR: Normalized Burn Ratio:  
 $(B8 - B12) / (B8 + B12)$



## Band merge

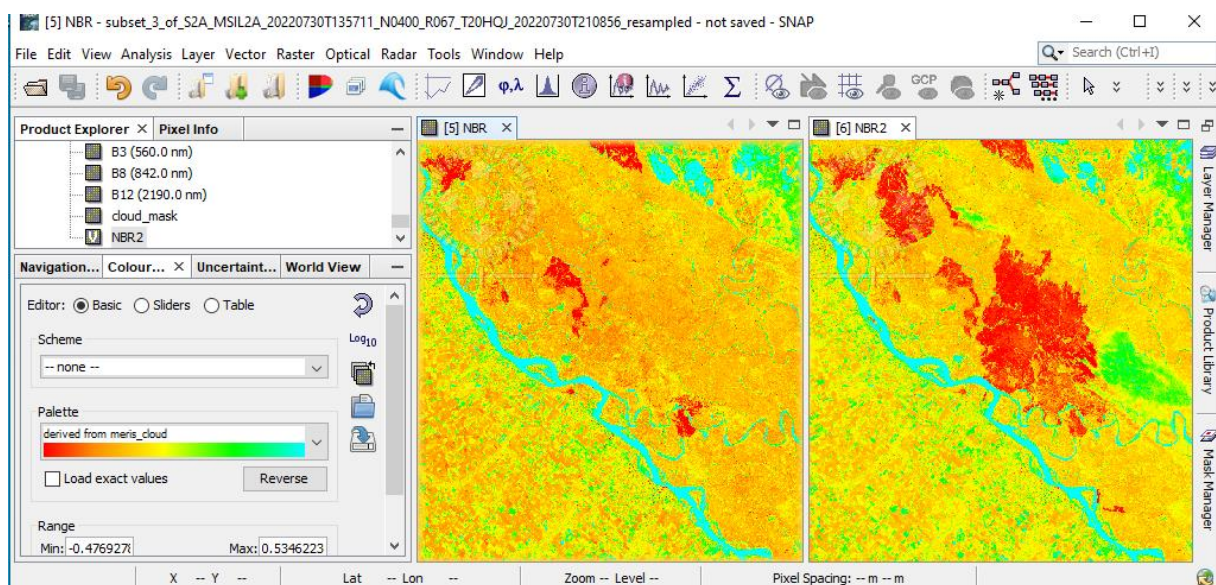
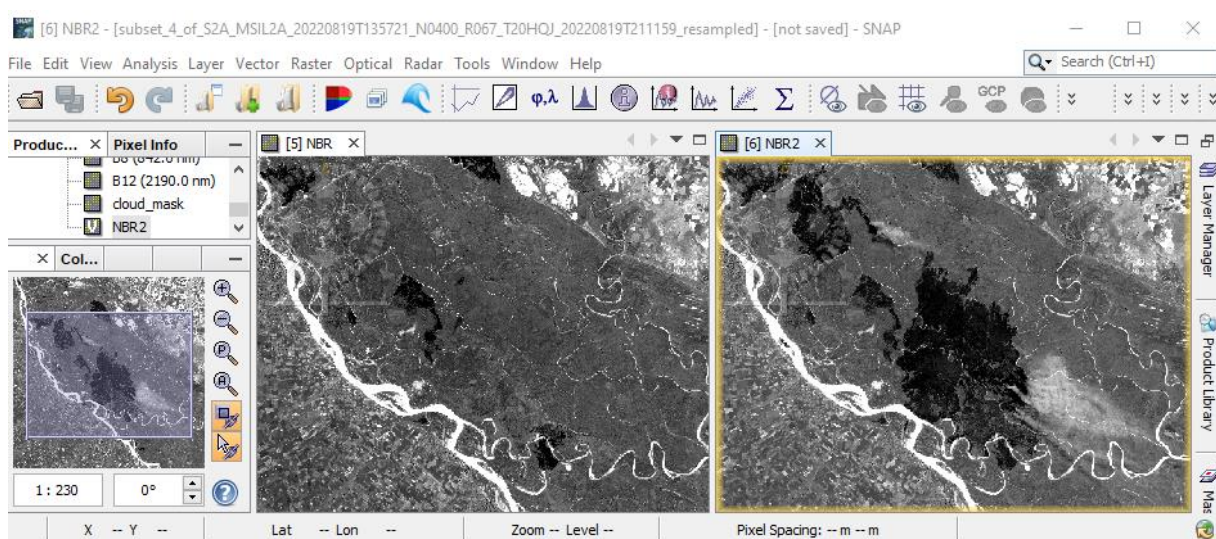
- Keep the source bands: **NBR, B3, B8, B12, cloud\_mask**



## Running and visualizing the NBR band

Try a color table:

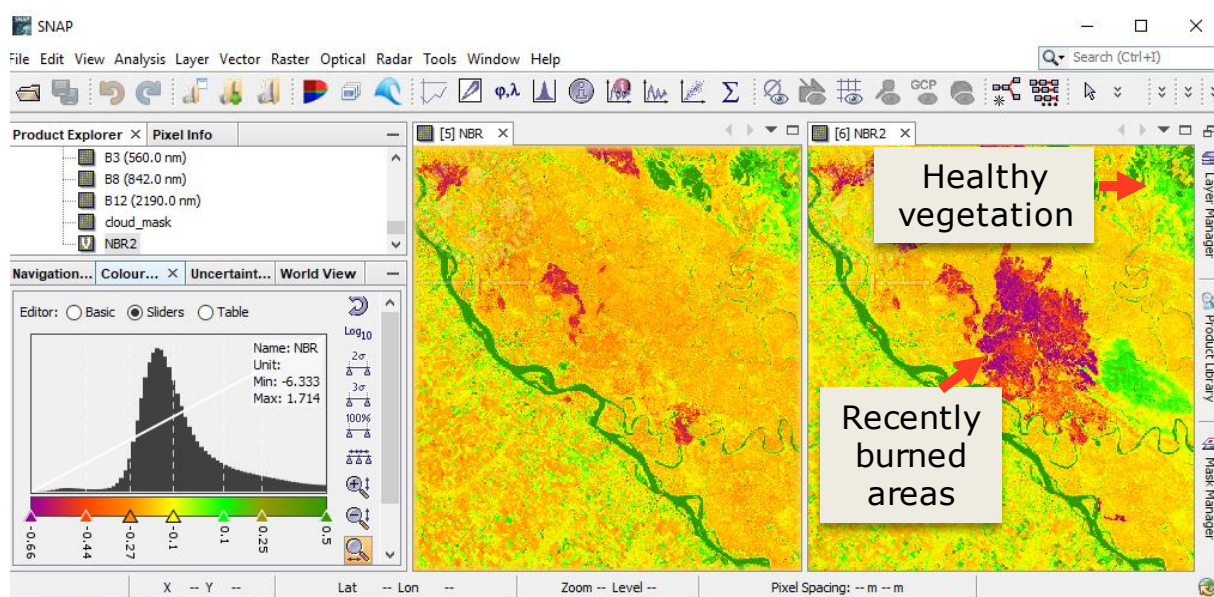
- Colour manipulation: Open color table, choose a color gradient, e.g. „derived from meris\_cloud“





You can also set the position of sliders and color them for better visualization or change ranges of values in the Table tab.

**NBR ranges between -1 and 1. A high NBR value indicates healthy vegetation. A low value indicates bare ground and recently burnt areas. Non-burnt areas usually have values close to zero.**

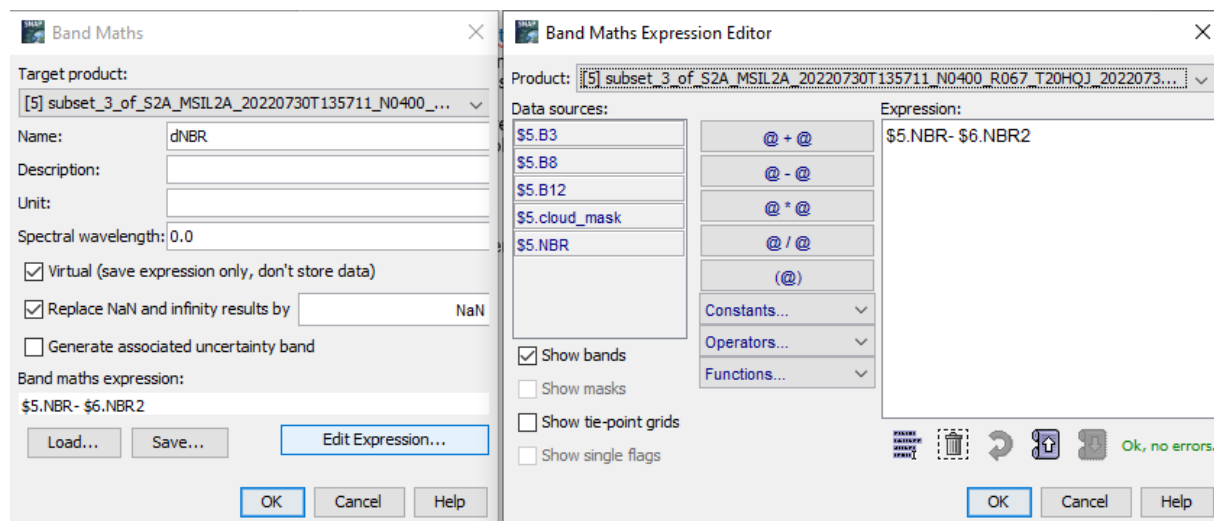


### Burn severity - dNBR

The difference between the pre-fire and post-fire NBR obtained from the images is used to calculate the delta NBR (dNBR or  $\Delta$ NBR), which then can be used to estimate the burn severity. A higher value of dNBR indicates more severe damage, while areas with negative dNBR values may indicate regrowth following a fire. The formula used to calculate dNBR is illustrated below:

$$\text{dNBR or } \Delta\text{NBR} = \text{PrefireNBR} - \text{PostfireNBR}$$

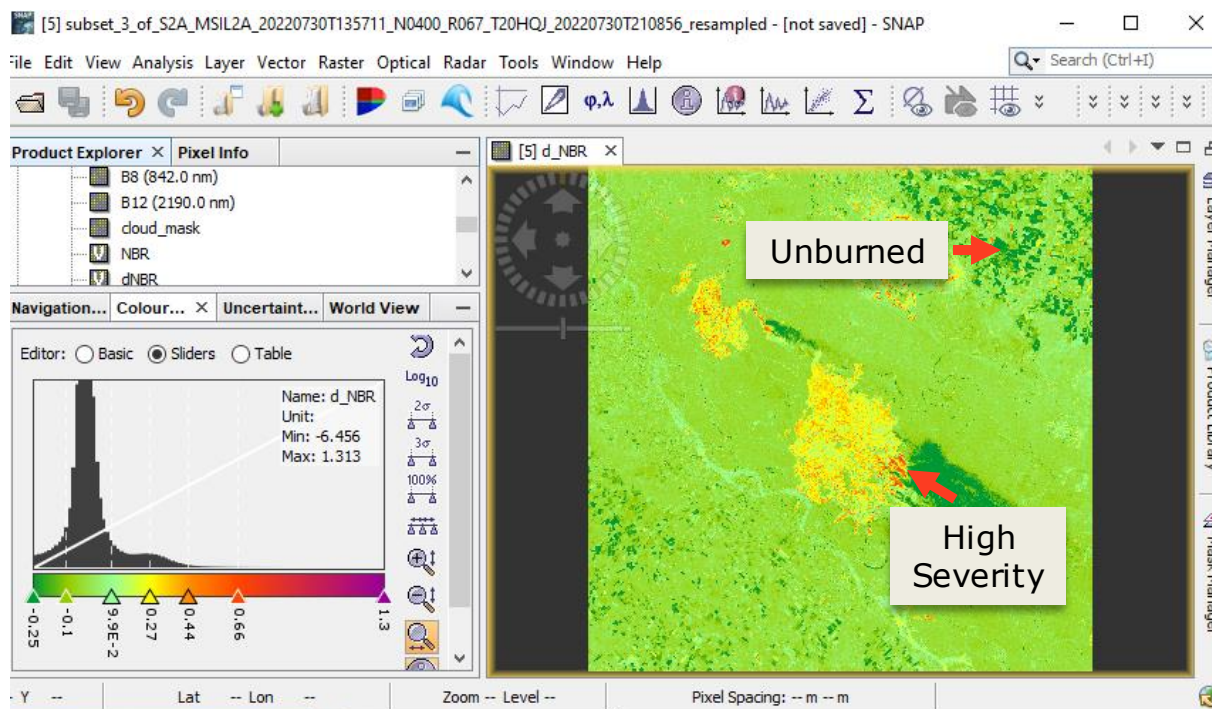
Go to Raster – Band Maths and Edit Expression



Set the position of sliders and color them for better visualization or change ranges of values in the Table tab.

**NBR ranges between -1 and 1. A high NBR value indicates healthy vegetation. A low value indicates bare ground and recently burnt areas. Non-burnt areas usually have values close to zero.**

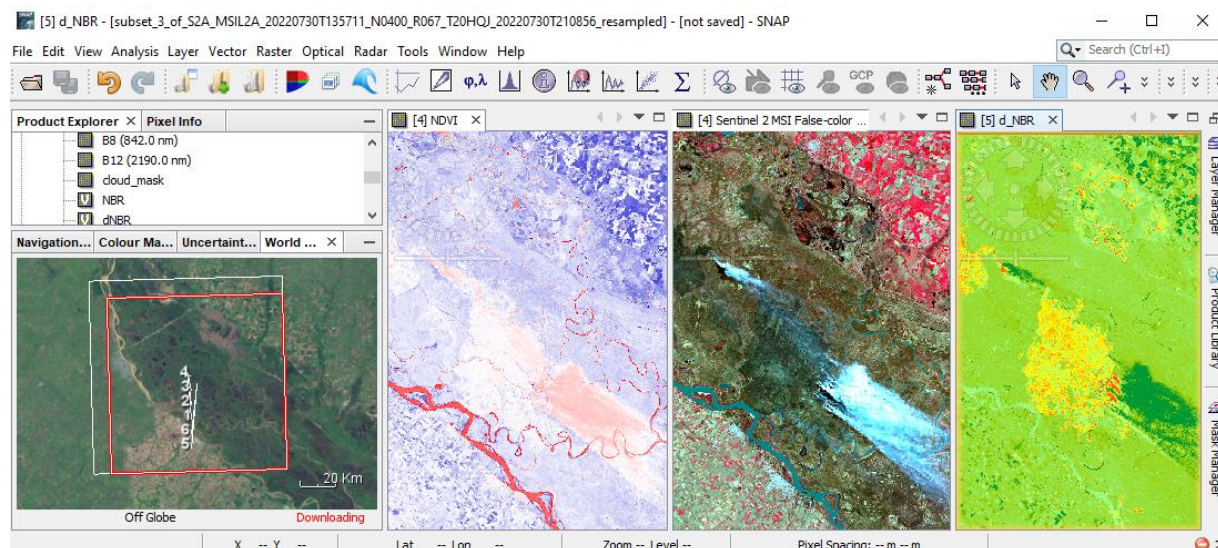
dNBR values can vary from case to case, and so, if possible, interpretation in specific instances should also be carried out through field assessment; in order to obtain the best results. However, the United States Geological Survey (USGS) proposed a classification table to interpret the burn severity, which can be seen below in the table.



Severity Level	dNBR Range (scaled by $10^3$ )	dNBR Range (not scaled)
Enhanced Regrowth, high (post-fire)	-500 to -251	-0.500 to -0.251
Enhanced Regrowth, low (post-fire)	-250 to -101	-0.250 to -0.101
Unburned	-100 to +99	-0.100 to +0.99
Low Severity	+100 to +269	+0.100 to +0.269
Moderate-low Severity	+270 to +439	+0.270 to +0.439
Moderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

## Comparison: Severity map, NDVI and false color composition

To compare different views of the same area and explore it more in detail, create also NDVI and false color composition. You can observe, that areas with high NDVI values correspond to the barren areas affected by wildfires. False color composition also depicts areas affected by fire – these areas are shown in dark pixels. False color composite B8-B4-B3 of the Sentinel 2 image (during fire), with superimposed ongoing wildfire sites, note that the smoke direction is corresponding to the wind direction.



**THANK YOU FOR FOLLOWING THE EXERCISE!**