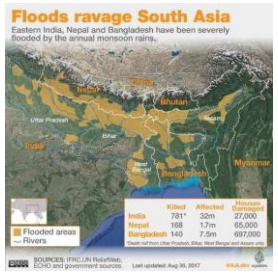
Flood Monitoring with Sentinel-1 & Sentinel-2 using the SNAP software

First exercise:
Detecting flooded areas on Sentinel-1 image

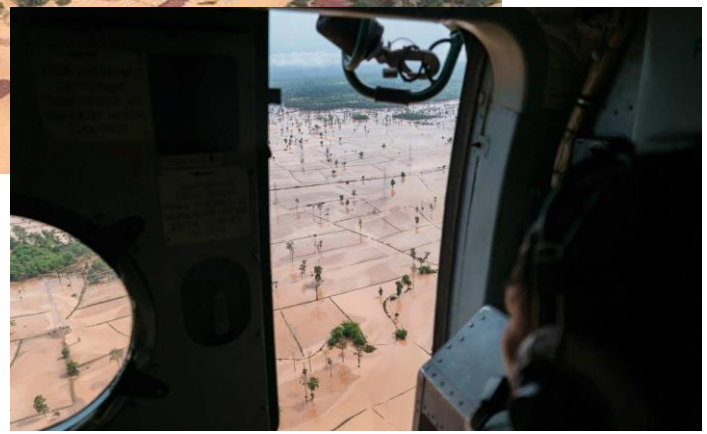
Flood Detection - Spain 2018

Floods account for 40% OF ALL NATURAL DISASTERS WORLDWIDE



Bangladesh

Heavy rain began falling over the weekend (09 to 10 June, 2018). Cox's Bazar has recorded over 300 mm of rain in 48 hours to 12 June.

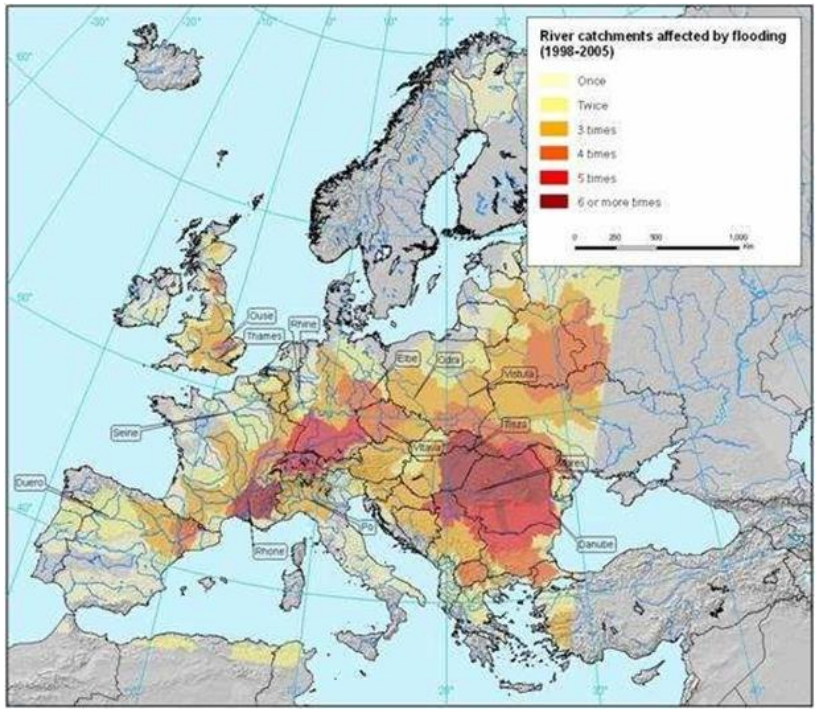


More than 13,000 were affected by the flooding from the Xe Pian Xe Namnoy dam collapse (southwestern Laos' Champassak province).

Flood Detection - Spain 2018

Floods account for 40% OF ALL NATURAL DISASTERS WORLDWIDE

Catastrophic floods cause human tragedy, endanger lives and bring heavy economic losses.



Credit by https://www.eea.europa.eu/themes/water/water-resources/floods

In addition to **economic and social damage**, floods can have severe environmental consequences, for example when installations holding large quantities of toxic chemicals are inundated.

The coming decades are likely to see a higher flood risk in Europe and greater economic damage.
Some areas have been more affected than others.

Between 1998 and 2005 north-western Romania, south-eastern France, central and southern Germany, northern Italy, and eastern England experienced the highest concentration of repeated flooding.

Spain, April 2018

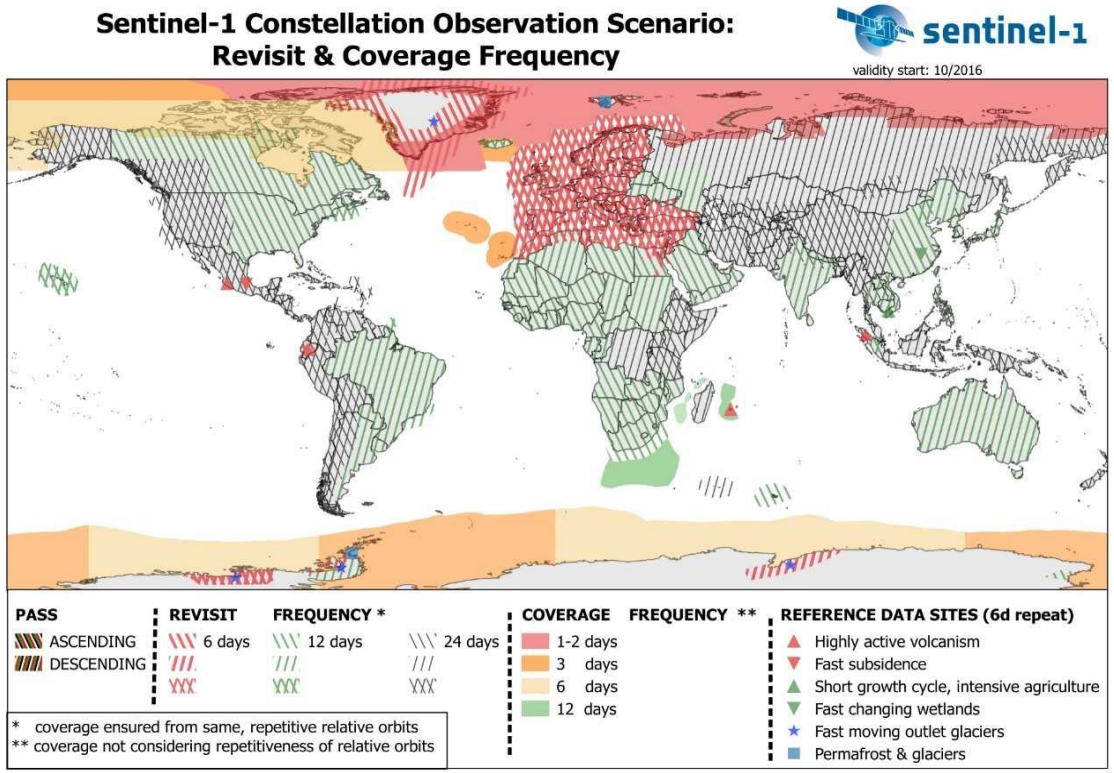
Flood event in April around Zaragoza from April 17th to 19th, 2018, due to Ebro river swelling from heavy rain during the previous weekend.

Active Microwave Remote Sensing (SAR)

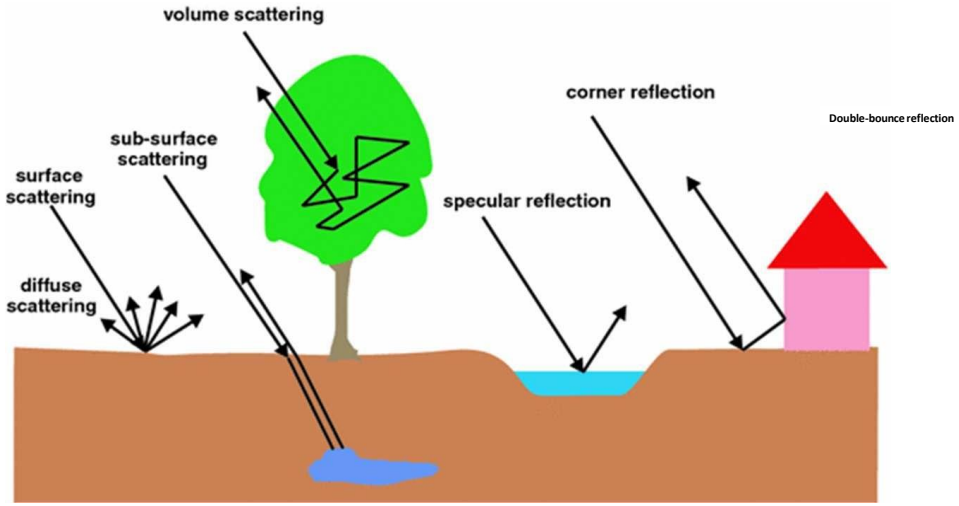
Advantage: Day and night measurement (active sensor) in all weather conditions

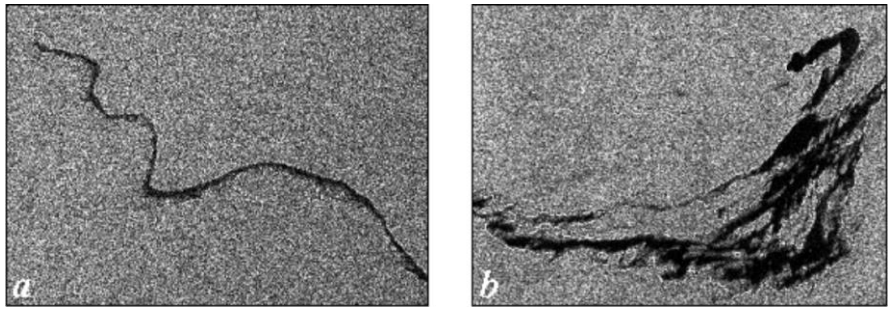
Previous drawbacks: Expensive imaging, long revisit time

Sentinel 1A/B Copernicus: Free Images (SciHub), short revisit time (**6 days** over Europe) (game changer)



Active Microwave Remote Sensing (SAR)





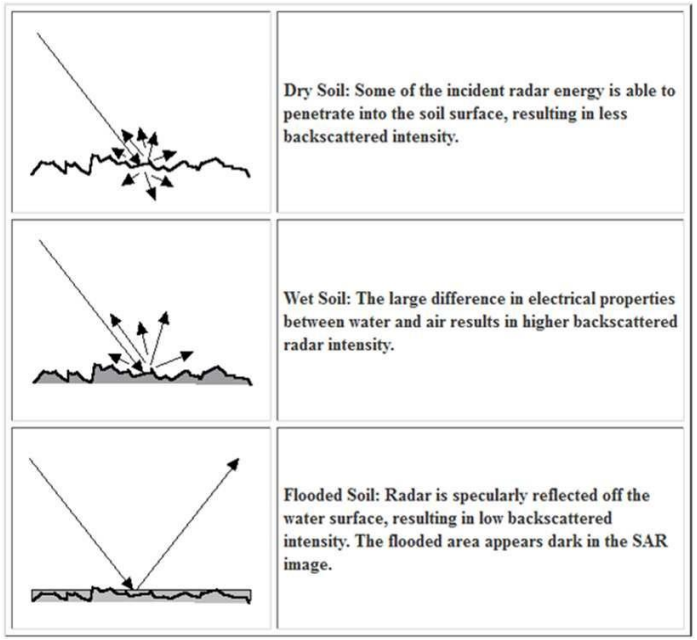
Courtesy of P.Trivero, W. Biamino,"Observing Marine Pollution with Synthetic Aperture Radar," 10.5772/9106

Roughness is a relative parameter…

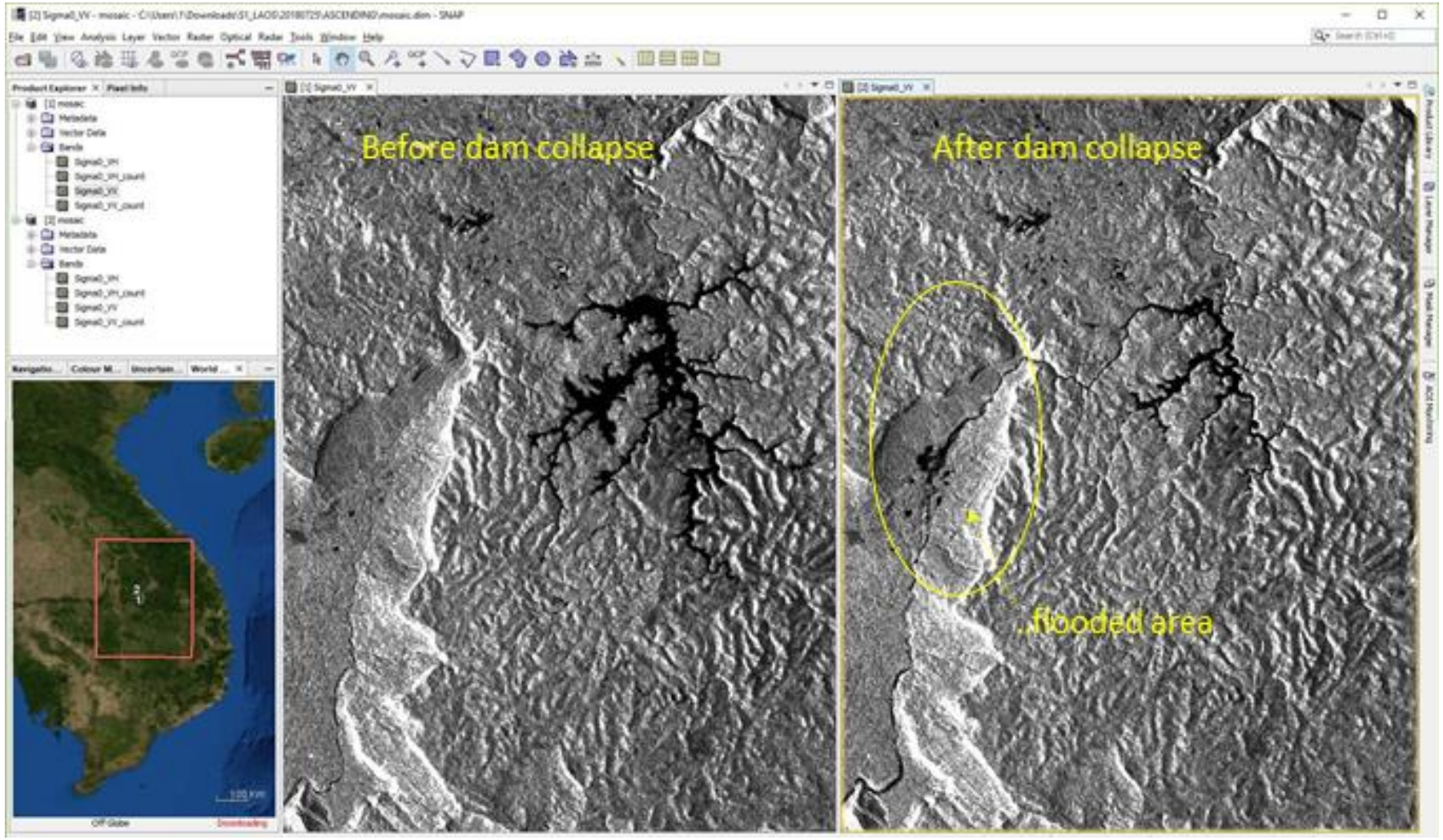
$h < \frac{\lambda}{8 \cdot \cos\theta}$

(Rayleigh)
h:surf mean height variation λ: wavelength,
Θ: incidence angle

Wind condition can increase the roughness over water and hence increase SAR backscattering

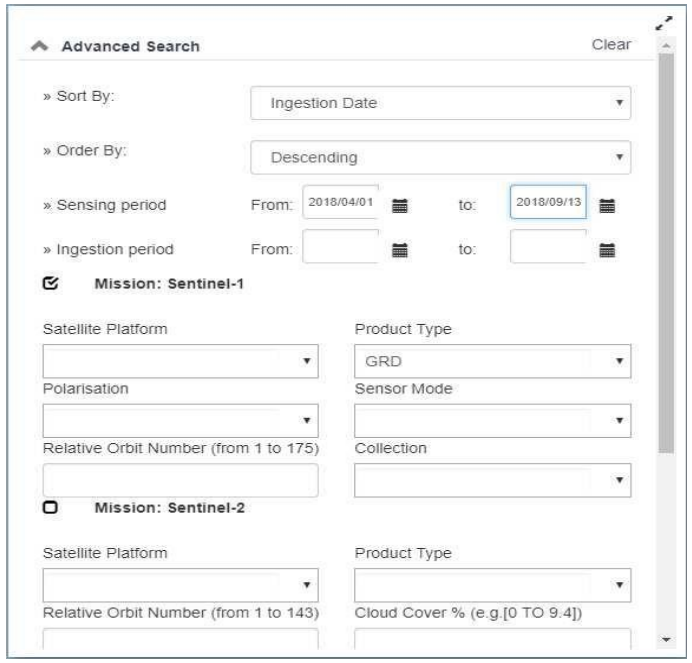


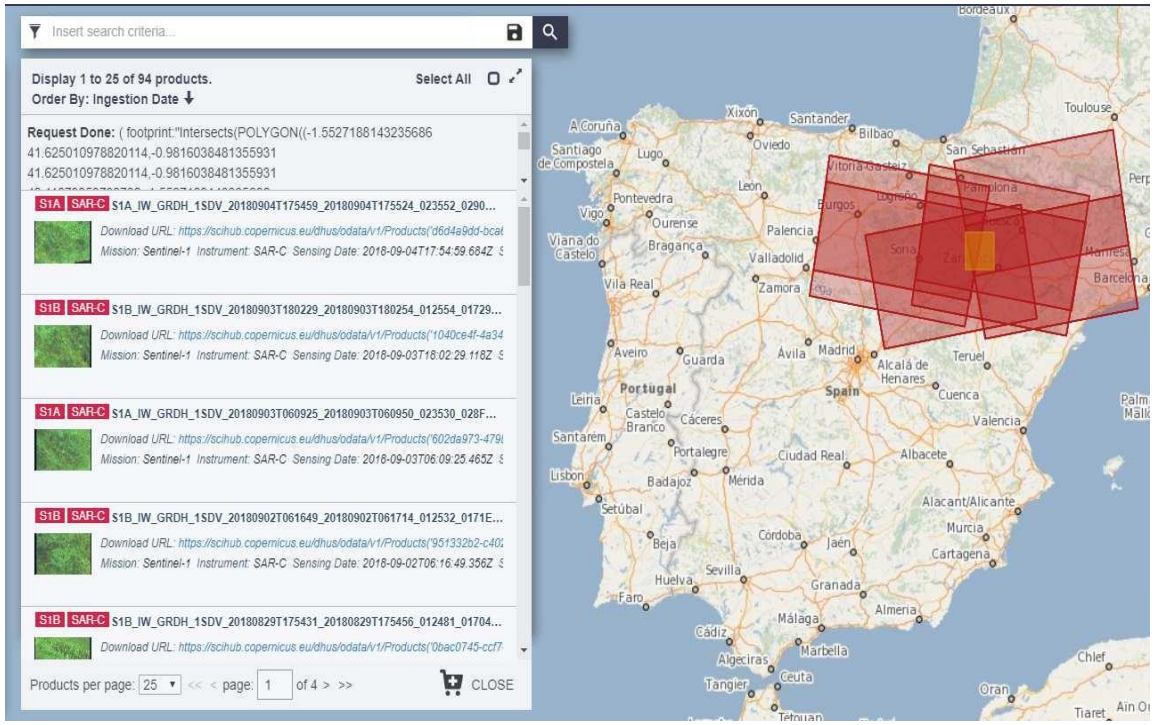
S1 data over Xe Pian Xe Namnoy area (Laos)



PART I : Data Search and Download

Activate **Filter** panel, select GRD in **Product Type** options for Sentinel 1 and timespan between April 1st to 13th, 2018.

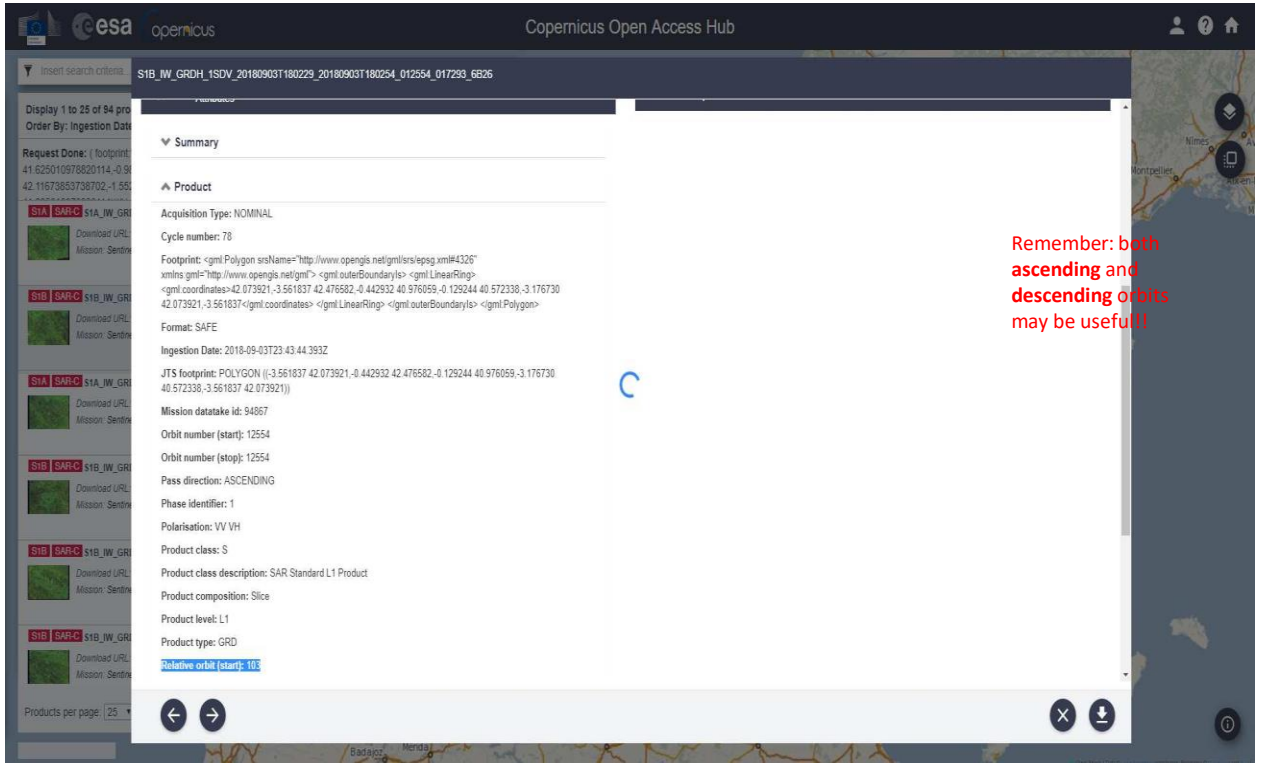




Expected results

PART I : Data Search and Download

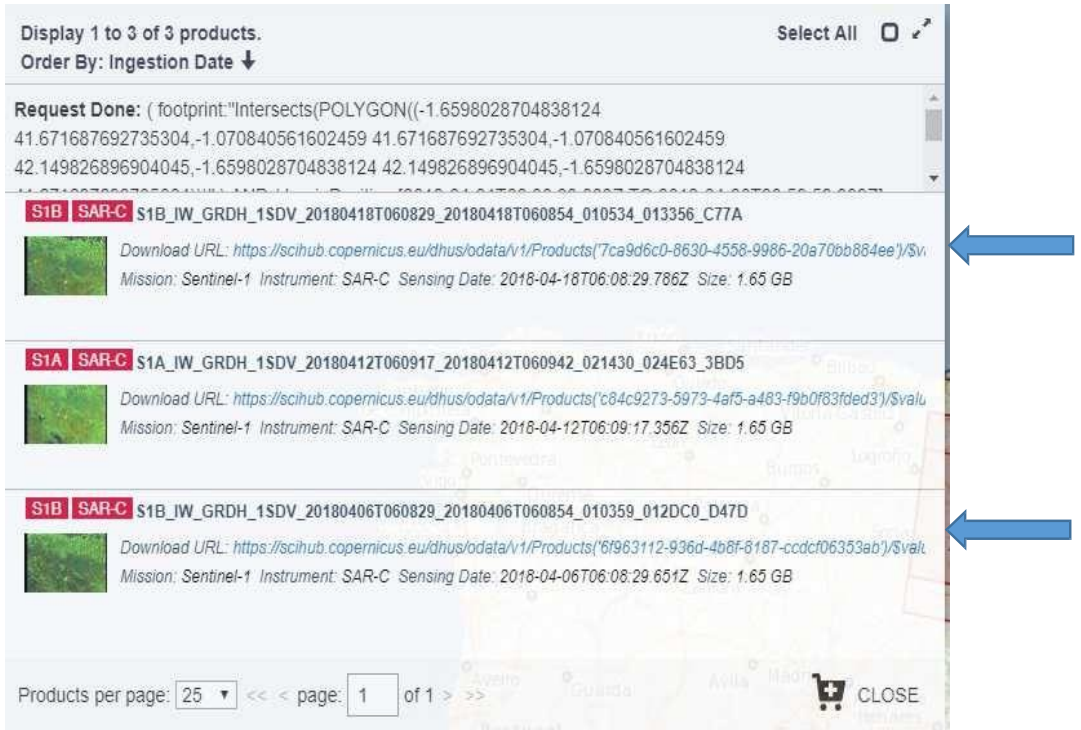
Different footprint covering the AOI (partial of total coverages).
Find the 4 Orbits



PART I : Data Search and Download

For this exercise, we will use 2 acquisition of the orbit 8, corresponding to April 6th and 18th, 2018.
The data (in zip format) have been already downloaded in the folder

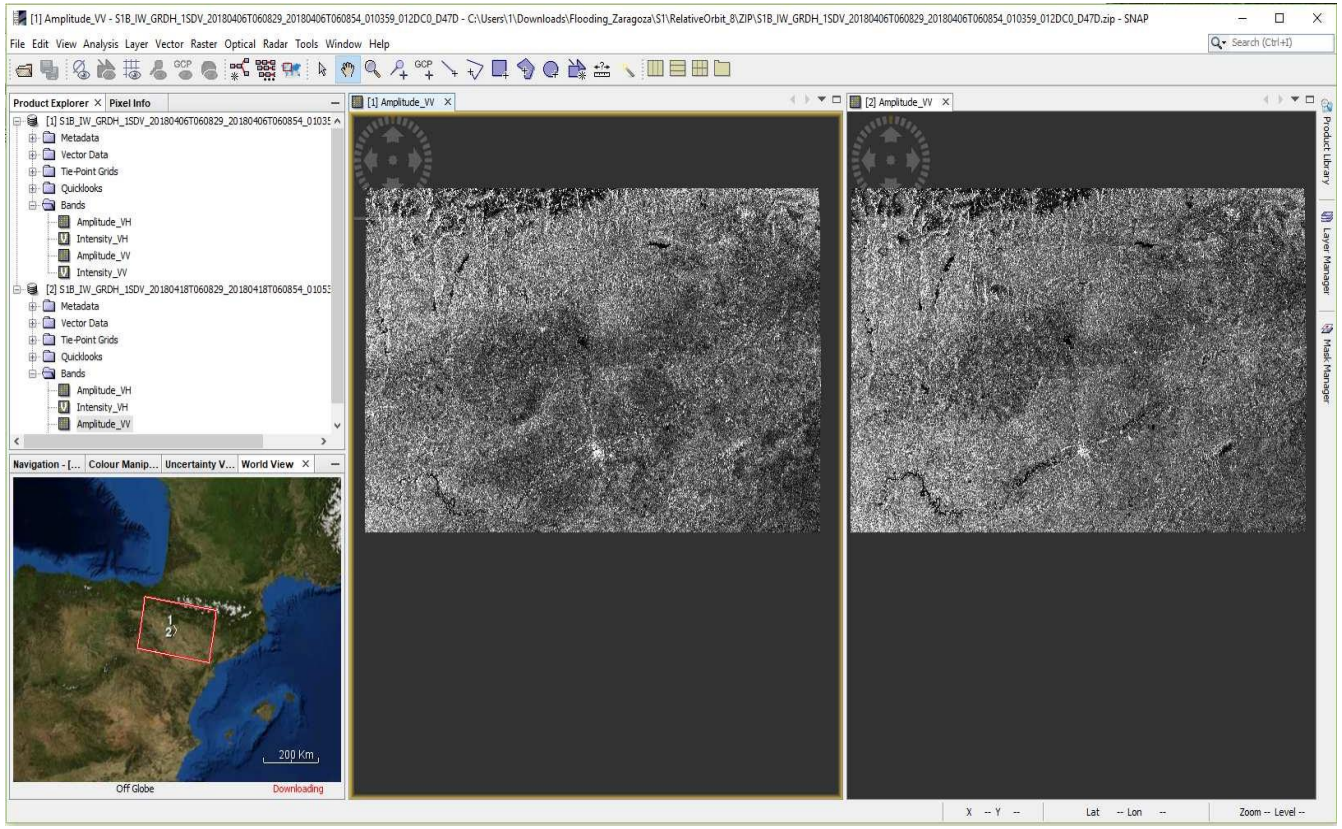
Orbit 8



PART II : Data Navigation and Preprocess

Open SNAP and EXPLORE data: load the images corresponding to Orbit Number 8 within the folder **../PECS_Slovakia/flood/extra_case_study/S1**

*S1B_IW_GRDH_1SDV_**20180406**T060829_20180406T060854_010359_012DC0_D47D*
*S1B_IW_GRDH_1SDV_**20180418**T060829_20180418T060854_010534_013356_C77A*



*Click **+** to expand contents of the layers in Product Explorer and double click on **Amplitude_VV***

PART II : Data Navigation and Preprocess

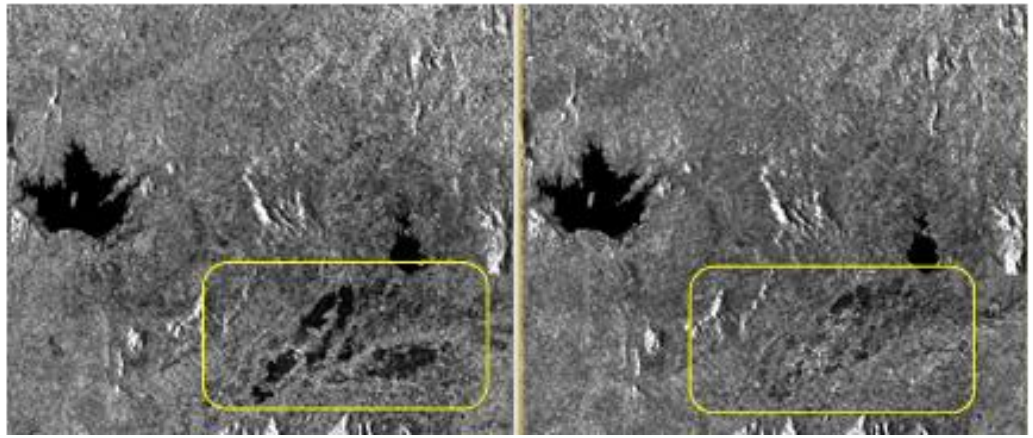
Theory pill

Sentinel 1 : two pol (VV and VH)

Hiigher return from vertical structure, or surface or double-bounce target

Higher return from vegetation (volumetric scattering)

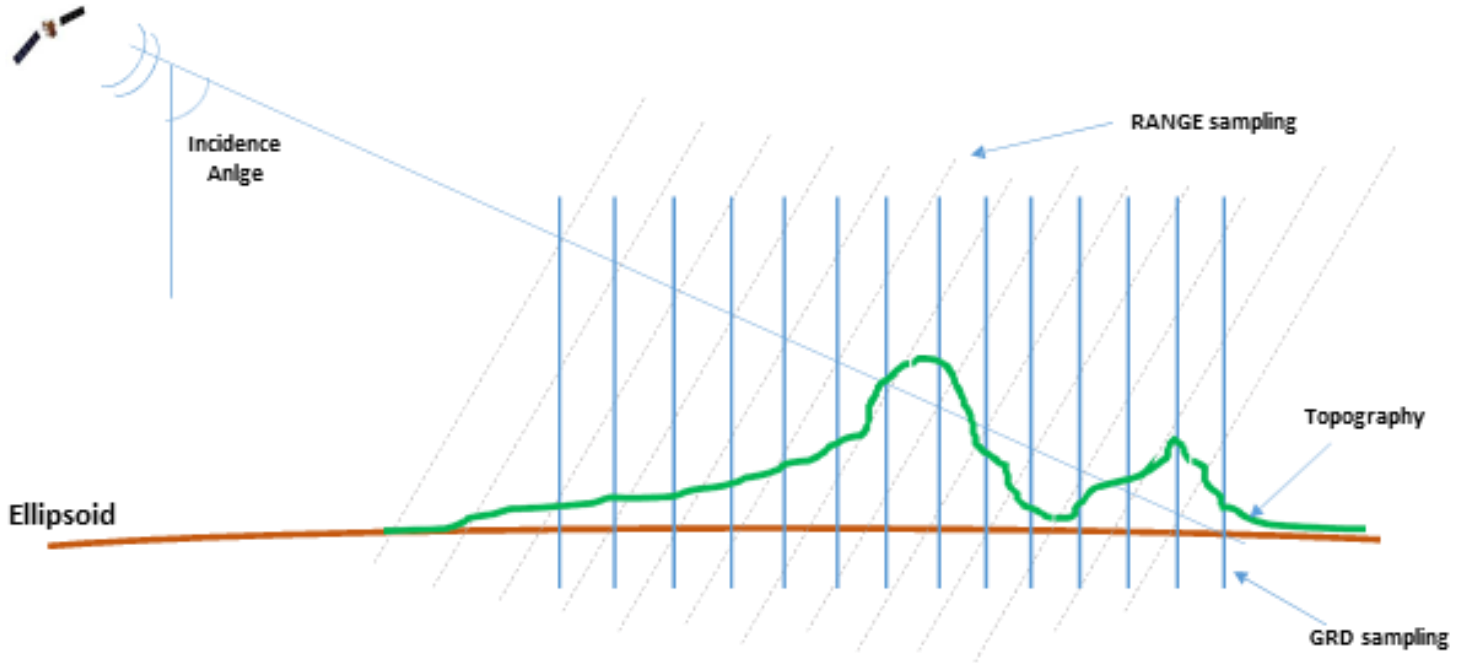
Lower return from flooded as well as flat areas. High false-positive rate



PART II : Data Navigation and Preprocess

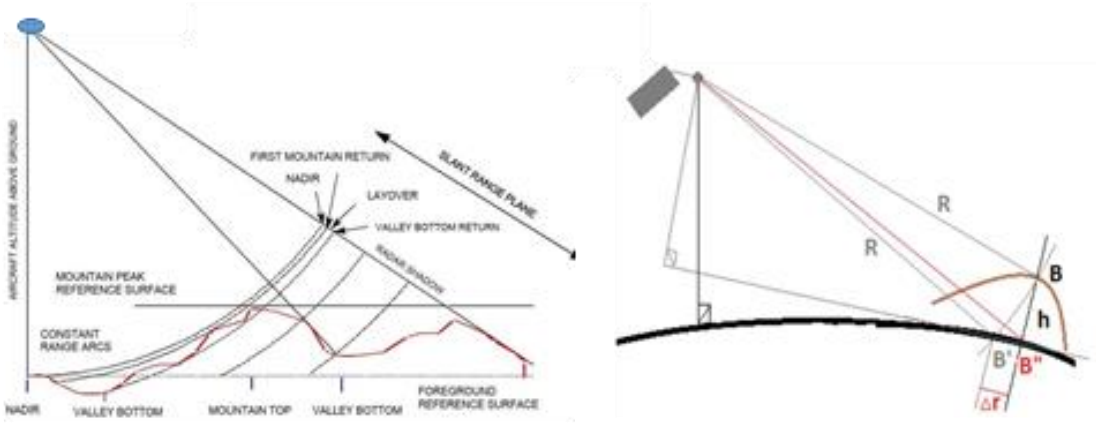
Despite the name ground or GRD images are not geocoded, but they are images define in a regular grid of the radar space observation:

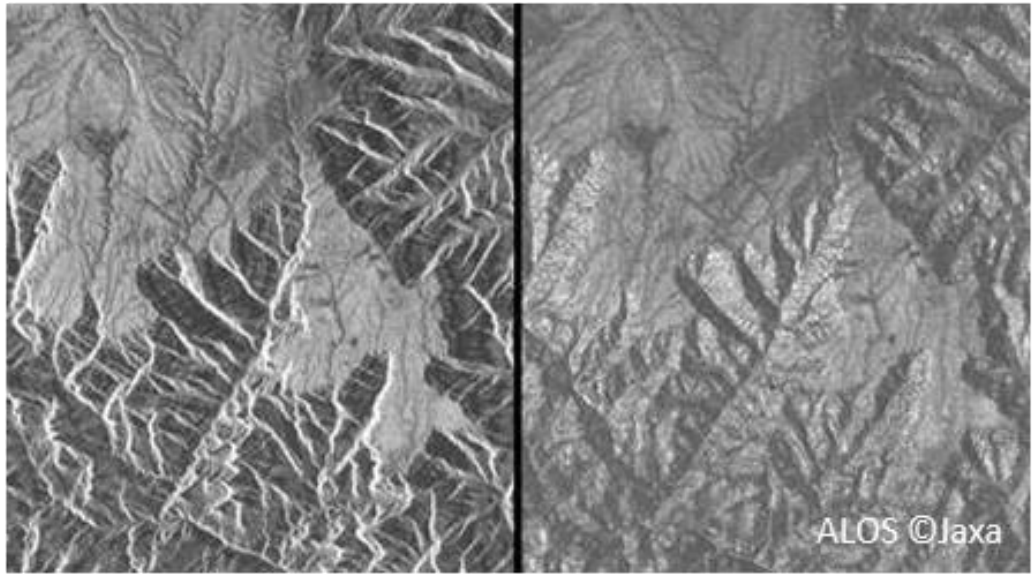
Level-1 Ground Range Detected (GRD) products consist of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model. Phase information is lost. For more info : https://sentinel.esa.int/web/sentinel/missions/sentinel-1/data-products



PART II : Data Navigation and Preprocess

GRD Images projected onto reference elipsoide **(no topography)**





Terrain Correction Project data from elipsoide to geographical coordinated take into account DEM

PART II : Data Navigation and Preprocess

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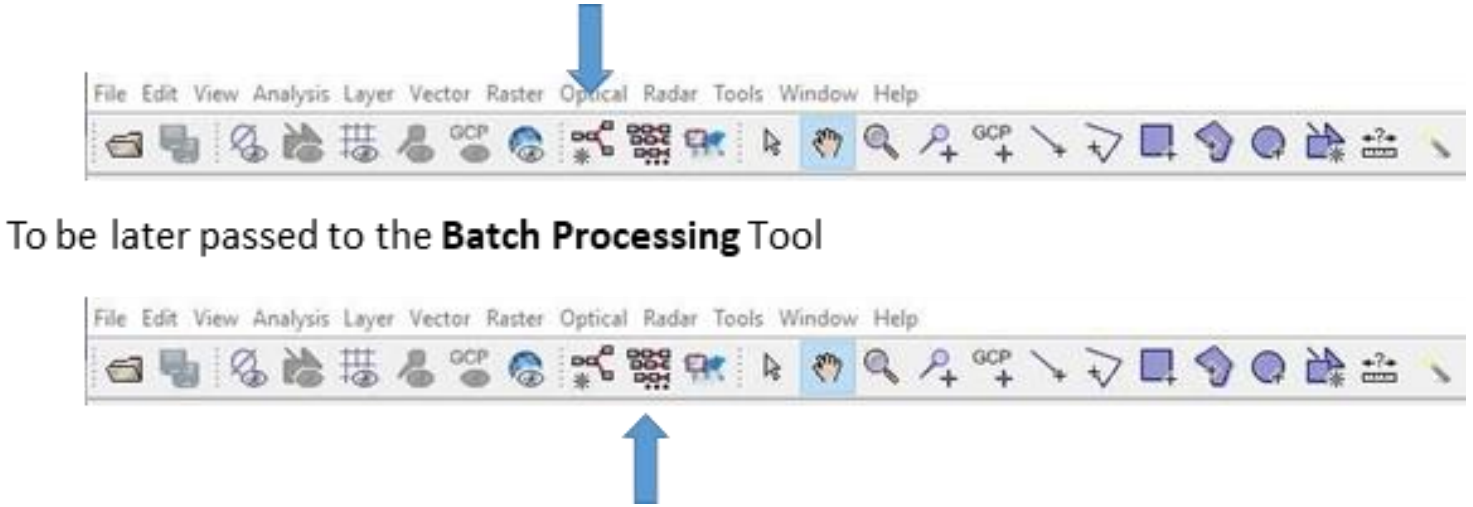
To convert GRD into geocoded information suited to flood detection, we need to perform some preprocessing steps.

As they must be applied to a collection of GRD images, we use to define a general **pre- processing graph**



PART II : Data Navigation and Preprocess

GraphBuilder

AOI Subset Definition (**Add->Raster->Geometric-> Subset**)

Apply precise Orbit file (**Add -> Radar -> Apply-Orbit-File)**

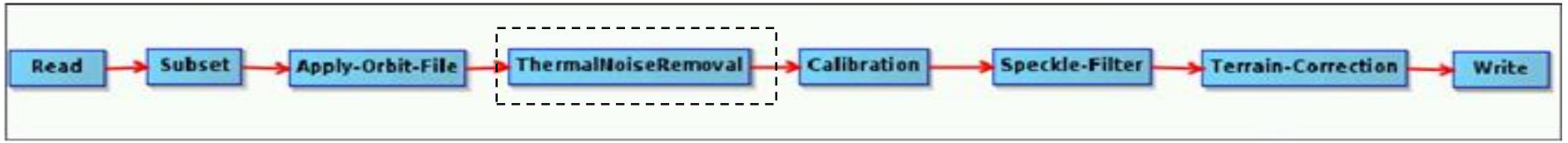
Remove the Thermal Noise (**Add->Radar->Radiometric->ThermalNoiseRemoval)**

Data Absolute Calibration (**Add -> Radar -> Radiometric -> Calibration)**

Speckle filtering (**Radar -> Speckle Filtering -> Speckle-Filter**

Terrain Correction filtering (**Radar -> Geometric -> Terrain Correction -> Terrain-Correction)**

PART II : Data Navigation and Preprocess



In the **Terrain-Correction** tab set **Map Projection -> Predefined CRS: AUTO: 42001 – WGS 84 / Auto UTM.** Leave all the other default settings.

In the **Speckle-Filter** tab, choose the simple Lee Sigma filter with window size of 7x7 pixels In the

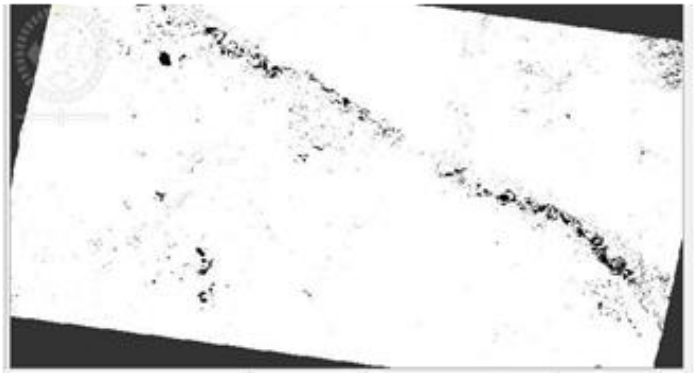
Subset tab set the extent of the AOI in pixel coordinates to:

X: **0** Y: **10000** Scene end X: **26000** Scene end Y: **16690**

PART III : Image Analysis and Water Mask Generation

Binarization: Water/Non-water separation by defining a suited threshold for each image.

- Open all two (preprocessed) products [3-4] in the View and then go to **Window -> Tile Evenly**
- Select the **Sigma0_VV** band corresponding to April 18th capture to activate it
- Select the Color Manipulation tab and click the Stretch Histogram Horizontally and then the logarithmic display Log_{10}
- Move the max, middle and minimum sliders around 0.023,0.015 and 0.009 on the histogram.

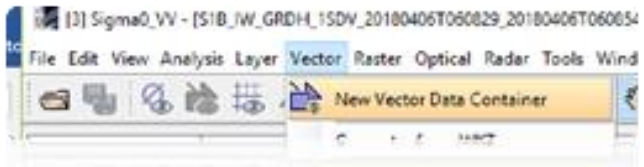


PART III : Image Analysis and Water Mask Generation

A binary mask of water and non-water pixels with a thresholding condition.

Define a Waterbody Region of Interest (ROI)

- Define a new ROI (**Vector->New Vector Data Container**)

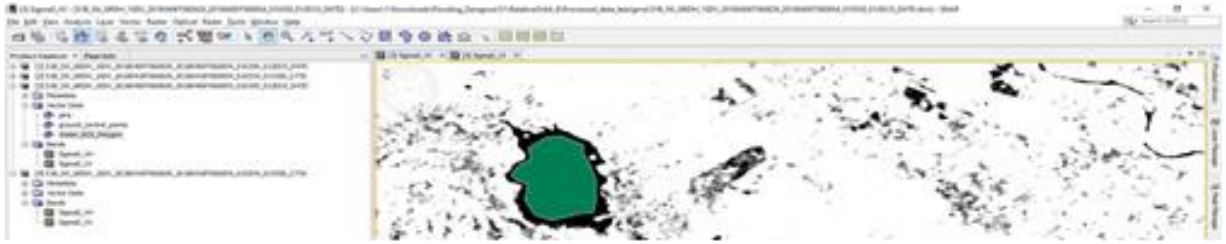


- Define ROI name (f.i. Water_ROI_Polygon_1) and description (optional)

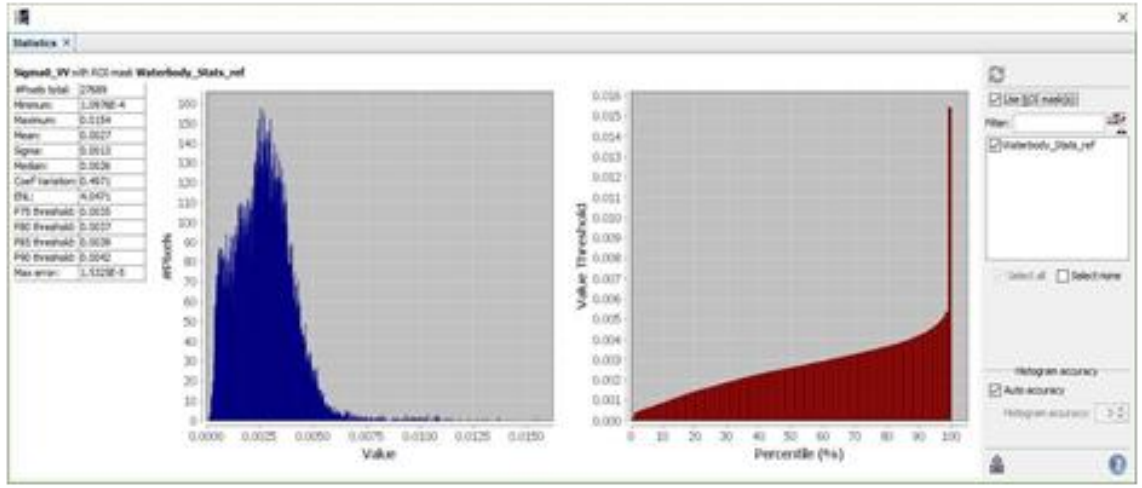
- Define Tool for ROI construction (Polygons Drawing Tool) 

PART III : Image Analysis and Water Mask Generation

- Draw polygon and doble-click to close it



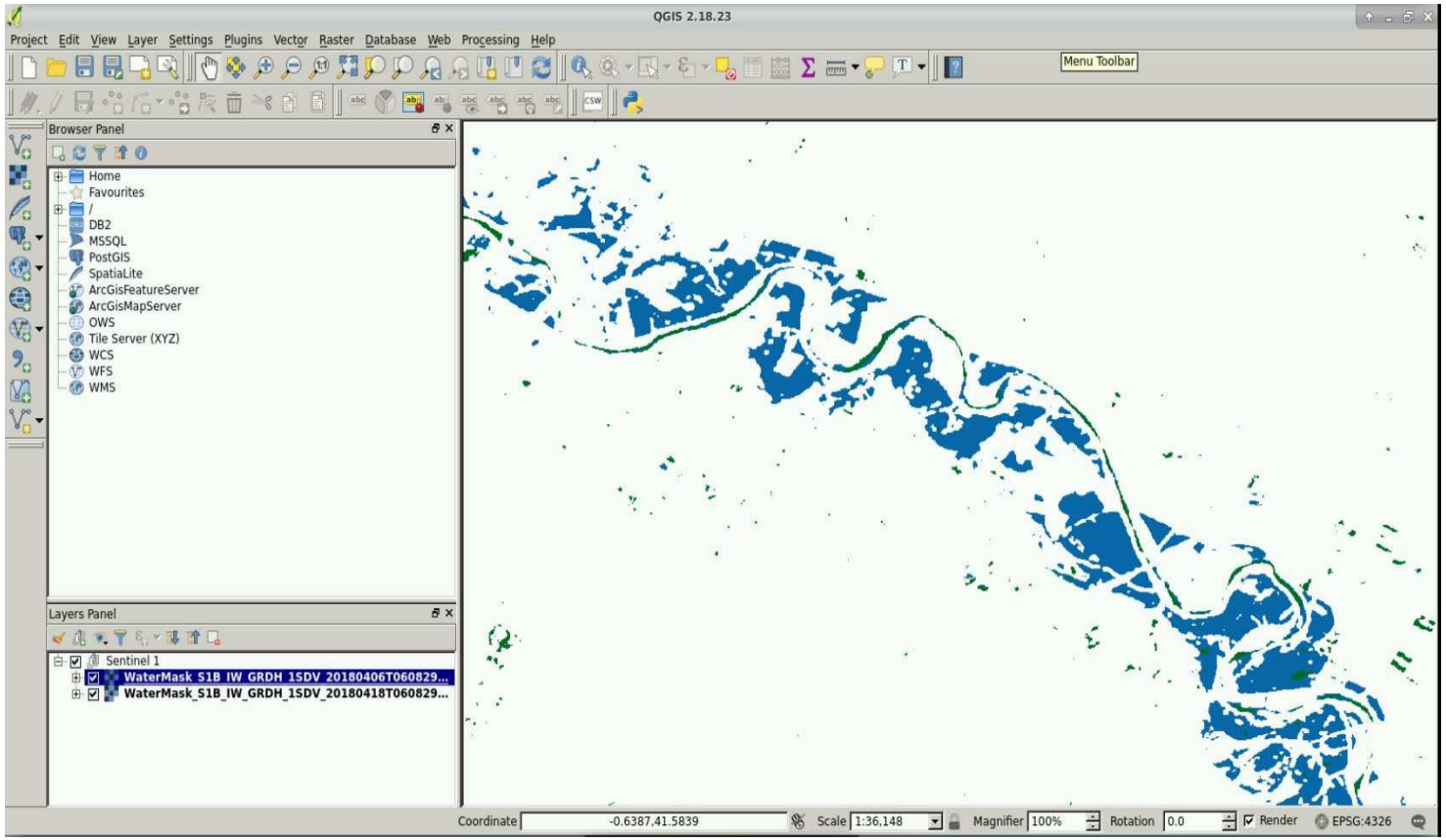
- Highlight Sigma0_VV layer (where ROI is defined), then go to **Analysis->Statistics**, select **Use Roi Mask** and **Water_ROI_Polygon**.



- Find value for Percentile 99 (move the mouse on the image to get values…)

PART IV : Results Visualization

The final result appears like this



Thank you for the attention