




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

ESA UNCLASSIFIED



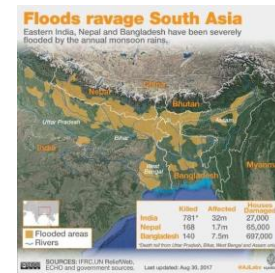


**First exercise:  
Detecting flooded areas on Sentinel-1 image**



# Flood Detection - Spain 2018

Floods account for **40%** OF ALL NATURAL DISASTERS WORLDWIDE

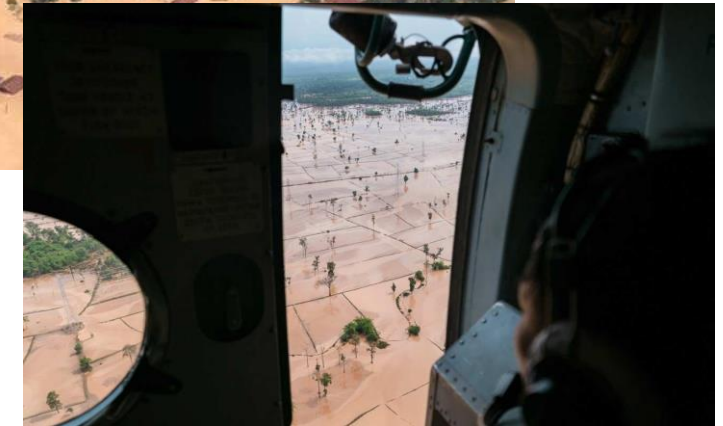


## Bangladesh

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.



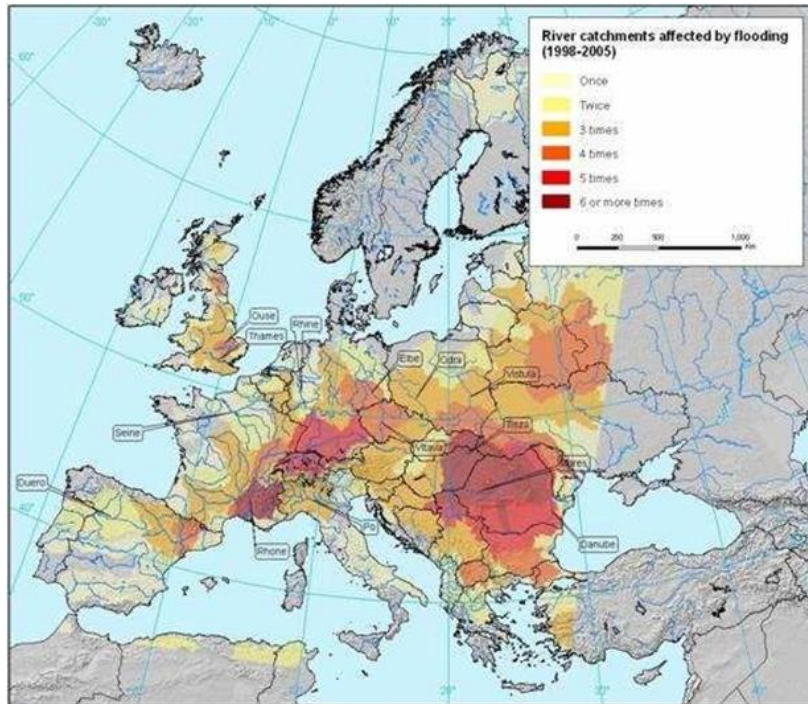
More than 13,000 were affected by the flooding from the Xe Pian Xe Namnoy dam collapse (southwestern Laos' Champassak province).



# 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.**



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 17<sup>th</sup> to 19<sup>th</sup>, 2018, due to Ebro river swelling from heavy rain during the previous weekend.



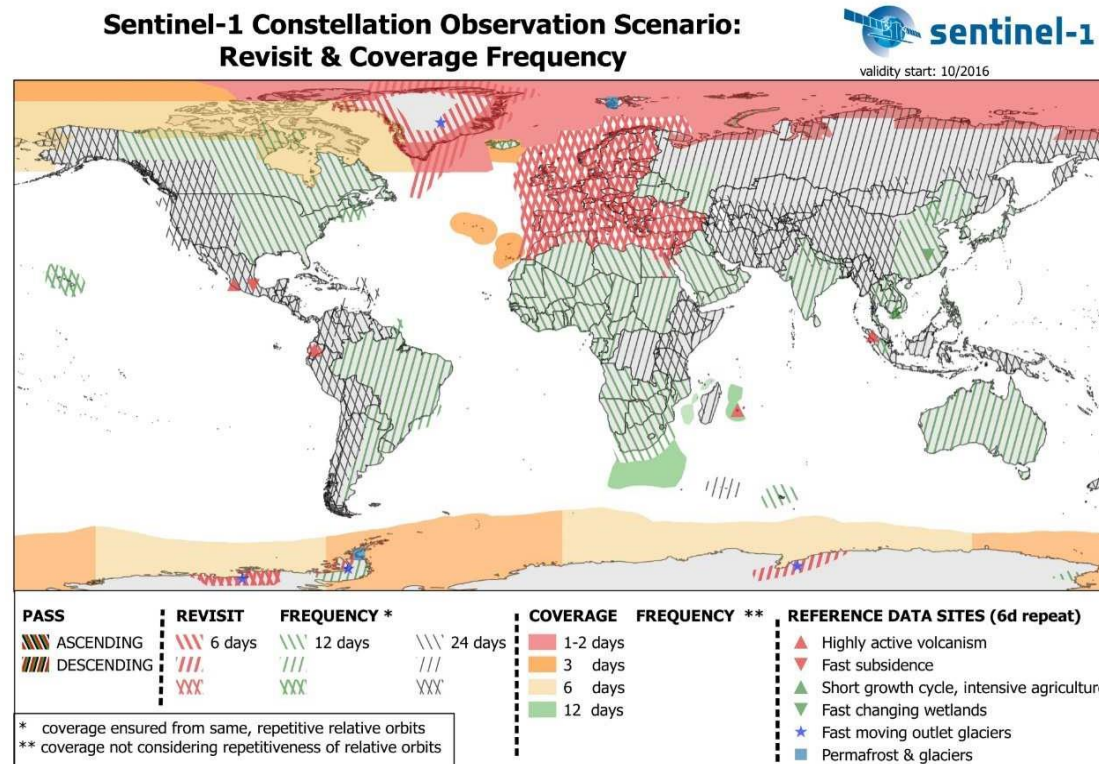
# Active Microwave Remote Sensing (SAR)

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

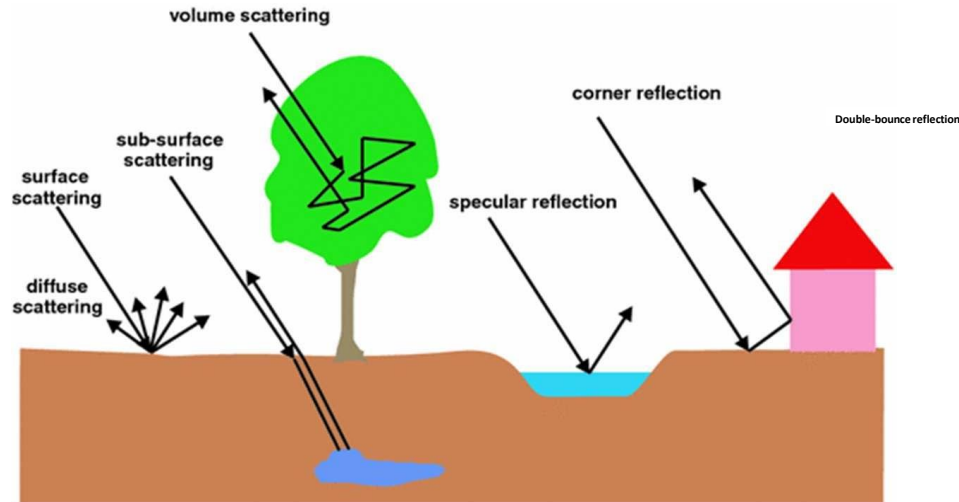
**Previous drawbacks:** Expensive imaging, long revisit time



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



# Active Microwave Remote Sensing (SAR)

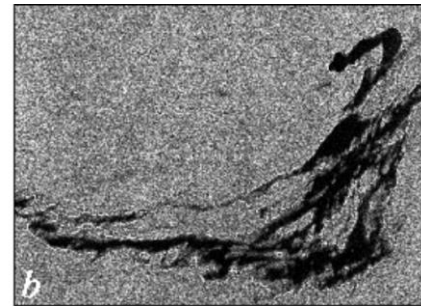
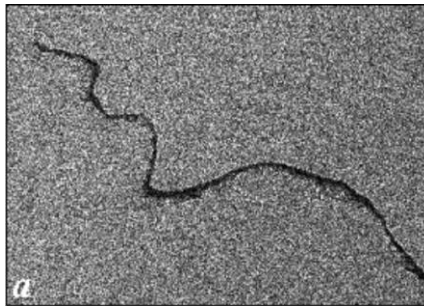


Roughness is a relative parameter...

$$h < \frac{\lambda}{8 \cdot \cos\theta} \quad (\text{Rayleigh})$$

$h$ : surf mean height variation  $\lambda$ : wavelength,  
 $\theta$ : incidence angle

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

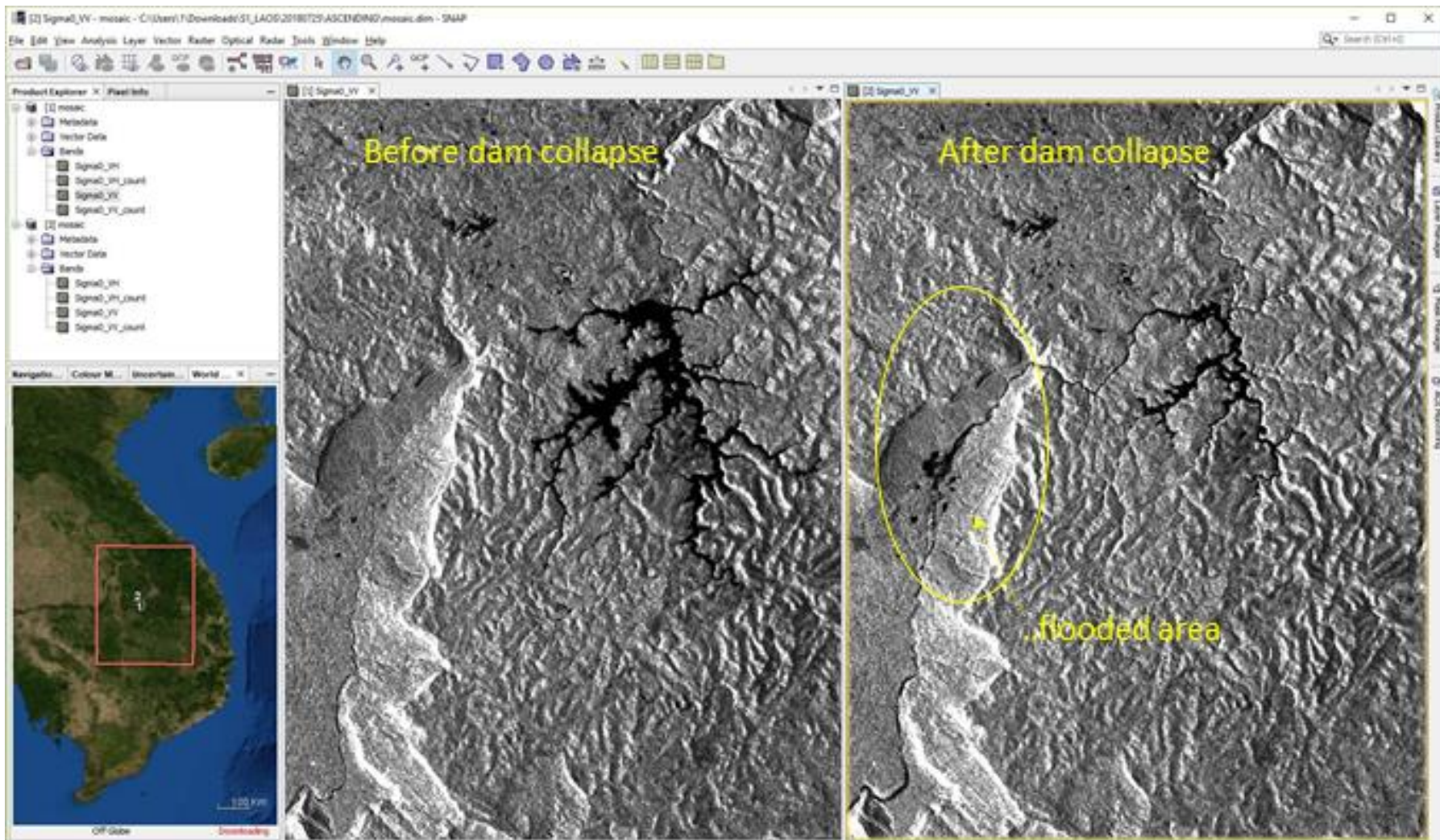


Courtesy of P.Trivero, W. Biamino, "Observing Marine Pollution with Synthetic Aperture Radar," 10.5772/9106

	<b>Dry Soil:</b> Some of the incident radar energy is able to penetrate into the soil surface, resulting in less backscattered intensity.
	<b>Wet Soil:</b> The large difference in electrical properties between water and air results in higher backscattered radar intensity.
	<b>Flooded Soil:</b> Radar is specularly reflected off the water surface, resulting in low backscattered intensity. The flooded area appears dark in the SAR image.



# 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 1<sup>st</sup> to 13<sup>th</sup>, 2018.

The screenshot shows the 'Advanced Search' panel with the following settings:

- Sort By: Ingestion Date
- Order By: Descending
- Sensing period: From: 2018/04/01 to: 2018/09/13
- Ingestion period: From: [empty] to: [empty]
- Mission:  Sentinel-1
- Satellite Platform: [empty]
- Product Type: GRD
- Polarisation: [empty]
- Sensor Mode: [empty]
- Relative Orbit Number (from 1 to 175): [empty]
- Collection: [empty]
- Mission:  Sentinel-2
- Satellite Platform: [empty]
- Product Type: [empty]
- Relative Orbit Number (from 1 to 143): [empty]
- Cloud Cover % (e.g.[0 TO 9.4]): [empty]

The screenshot displays search results for Sentinel-1 SAR-C products. The results list includes:

- Request Done: ( footprint:"Intersects(POLYGON((-1.5527188143235686 41.625010978820114,-0.9816038481355931 41.625010978820114,-0.9816038481355931 41.625010978820114,-0.9816038481355931 41.625010978820114,-1.5527188143235686 41.625010978820114)))" )
- Product 1: S1A SAR-C S1A\_IW\_GRDH\_1SDV\_20180904T175459\_20180904T175524\_023552\_0290...  
Download URL: <https://scihub.copernicus.eu/dhus/odata/v1/Products/'d6c4a9dd-bca1-416b-8000-000119080000'>  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-09-04T17:54:59.684Z
- Product 2: S1B SAR-C S1B\_IW\_GRDH\_1SDV\_20180903T180229\_20180903T180254\_012554\_01729...  
Download URL: <https://scihub.copernicus.eu/dhus/odata/v1/Products/'1040ce4f-4e34-4000-8000-000119080000'>  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-09-03T18:02:29.116Z
- Product 3: S1A SAR-C S1A\_IW\_GRDH\_1SDV\_20180903T060925\_20180903T060950\_023530\_028F...  
Download URL: <https://scihub.copernicus.eu/dhus/odata/v1/Products/'602da973-479f-4000-8000-000119080000'>  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-09-03T06:09:25.463Z
- Product 4: S1B SAR-C S1B\_IW\_GRDH\_1SDV\_20180902T061649\_20180902T061714\_012532\_0171E...  
Download URL: <https://scihub.copernicus.eu/dhus/odata/v1/Products/'951332b2-c40f-4000-8000-000119080000'>  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-09-02T06:16:49.356Z
- Product 5: S1B SAR-C S1B\_IW\_GRDH\_1SDV\_20180829T175431\_20180829T175456\_012481\_01704...  
Download URL: <https://scihub.copernicus.eu/dhus/odata/v1/Products/'0bac0745-cc7f-4000-8000-000119080000'>

The map on the right shows the Iberian Peninsula with several red rectangular footprints overlaid, indicating the search area. The interface also shows 'Display 1 to 25 of 94 products', 'Order By: Ingestion Date', and 'Products per page: 25'.

Expected results





## PART I : Data Search and Download

---

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

### Orbit 8

Display 1 to 3 of 3 products. Select All  ↗

Order By: Ingestion Date ↓

**Request Done:** ( footprint:"Intersects(POLYGON((-1.6598028704838124 41.671687692735304,-1.070840561602459 41.671687692735304,-1.070840561602459 42.149826896904045,-1.6598028704838124 42.149826896904045,-1.6598028704838124 41.671687692735304,-1.070840561602459 41.671687692735304))" )

**S1B SAR-C** S1B\_IW\_GRDH\_1SDV\_20180418T060829\_20180418T060854\_010534\_013356\_C77A  
 Download URL: [https://scihub.copernicus.eu/dhus/odata/v1/Products\('7ca9d6c0-8630-4558-9986-20a70bb884ee'\)/\\$value](https://scihub.copernicus.eu/dhus/odata/v1/Products('7ca9d6c0-8630-4558-9986-20a70bb884ee')/$value)  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-04-18T06:08:29.786Z Size: 1.65 GB

**S1A SAR-C** S1A\_IW\_GRDH\_1SDV\_20180412T060917\_20180412T060942\_021430\_024E63\_3BD5  
 Download URL: [https://scihub.copernicus.eu/dhus/odata/v1/Products\('c84c9273-5973-4af5-a483-f9b0f83fcd3'\)/\\$value](https://scihub.copernicus.eu/dhus/odata/v1/Products('c84c9273-5973-4af5-a483-f9b0f83fcd3')/$value)  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-04-12T06:09:17.356Z Size: 1.65 GB

**S1B SAR-C** S1B\_IW\_GRDH\_1SDV\_20180406T060829\_20180406T060854\_010359\_012DC0\_D47D  
 Download URL: [https://scihub.copernicus.eu/dhus/odata/v1/Products\('6f963112-936d-4b8f-8187-ccdctf06353ab'\)/\\$value](https://scihub.copernicus.eu/dhus/odata/v1/Products('6f963112-936d-4b8f-8187-ccdctf06353ab')/$value)  
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2018-04-06T06:08:29.651Z Size: 1.65 GB

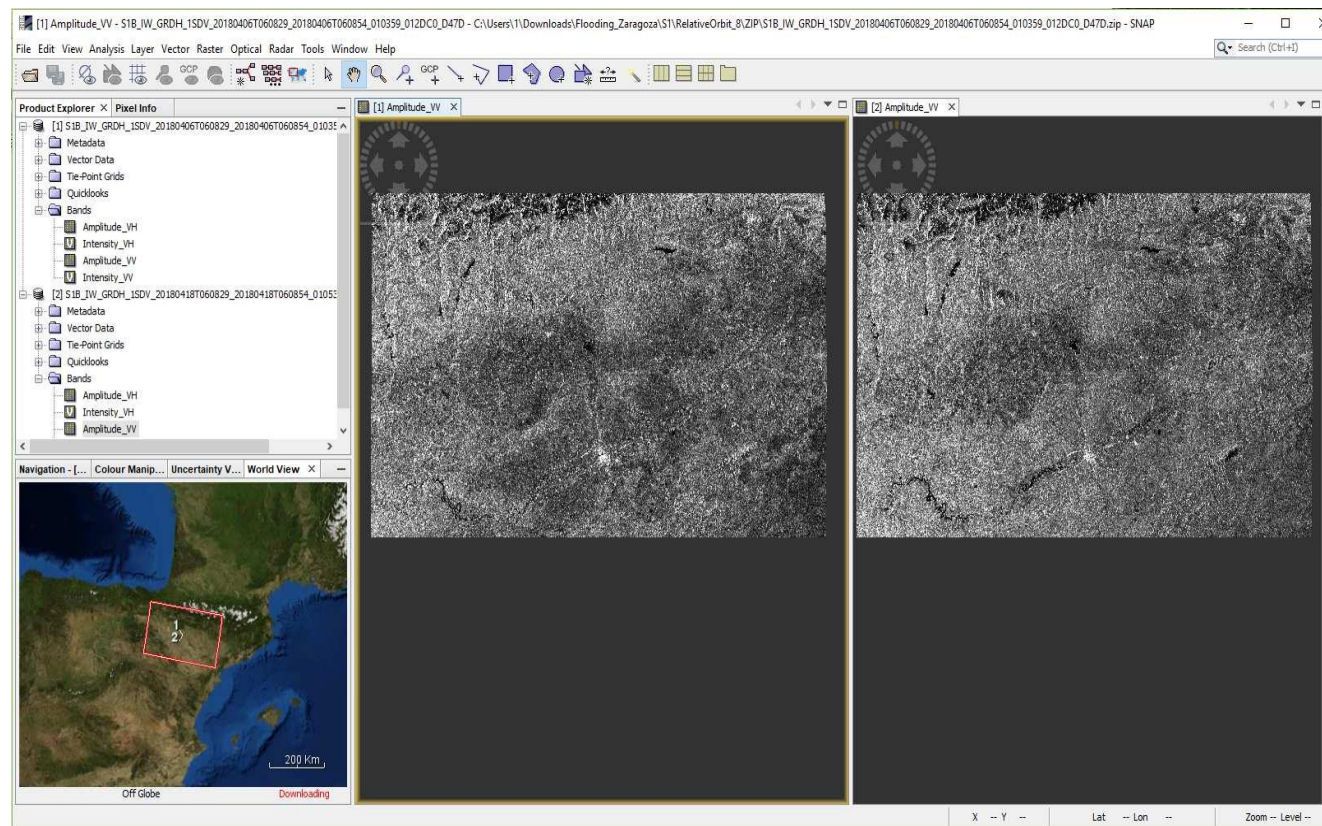
Products per page: 25 << < page: 1 of 1 > >>  CLOSE



## 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\_20180406T060829\_20180406T060854\_010359\_012DC0\_D47D***  
***S1B\_IW\_GRDH\_1SDV\_20180418T060829\_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



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

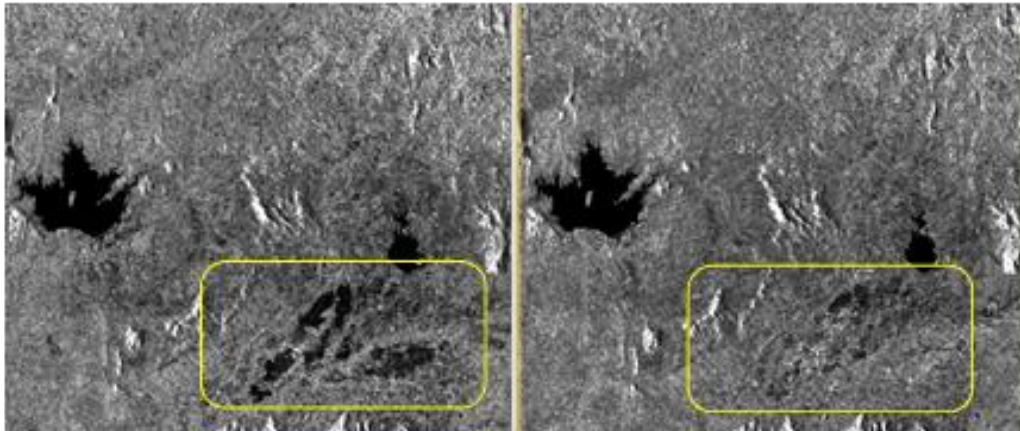


### Sentinel 1 : two pol (VV and VH)

Higher return from vegetation (volumetric scattering)



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





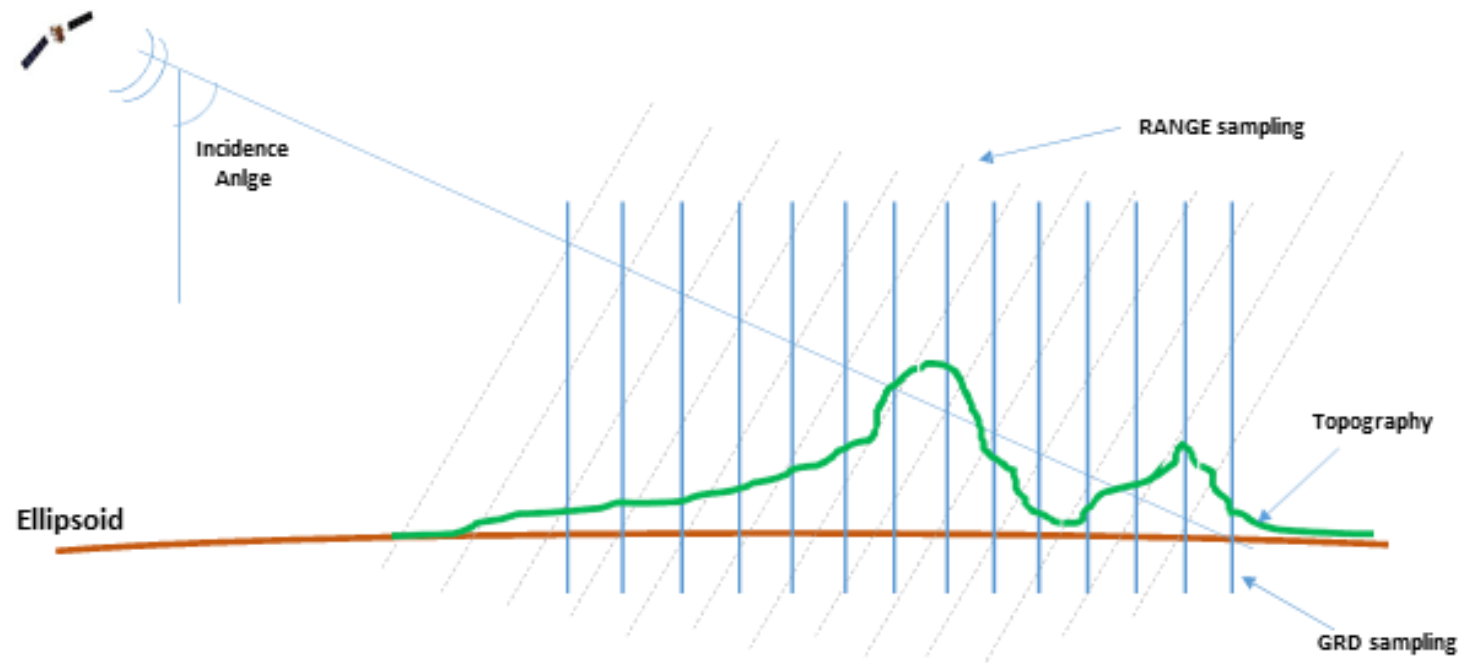
## PART II : Data Navigation and Preprocess

---

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

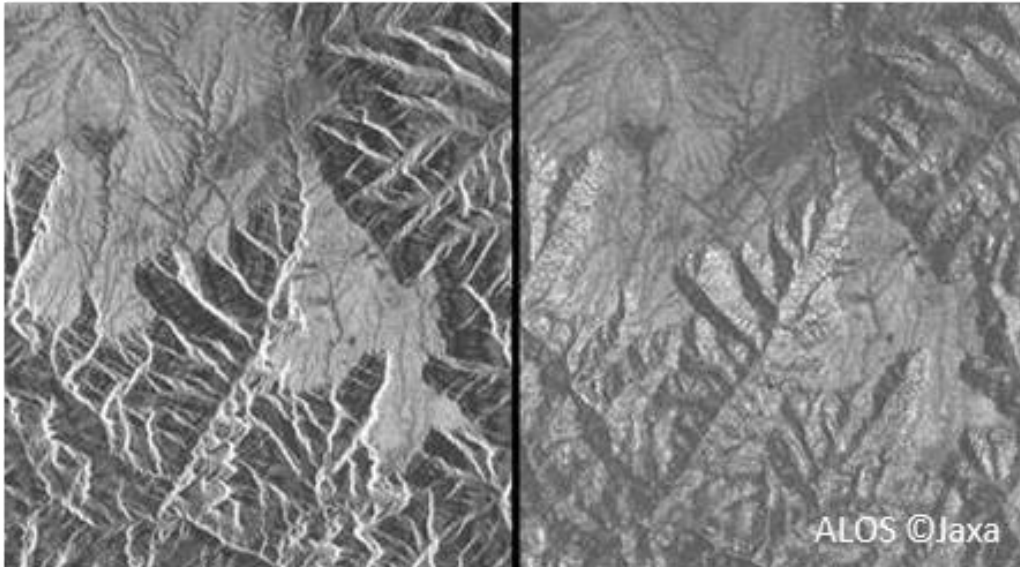
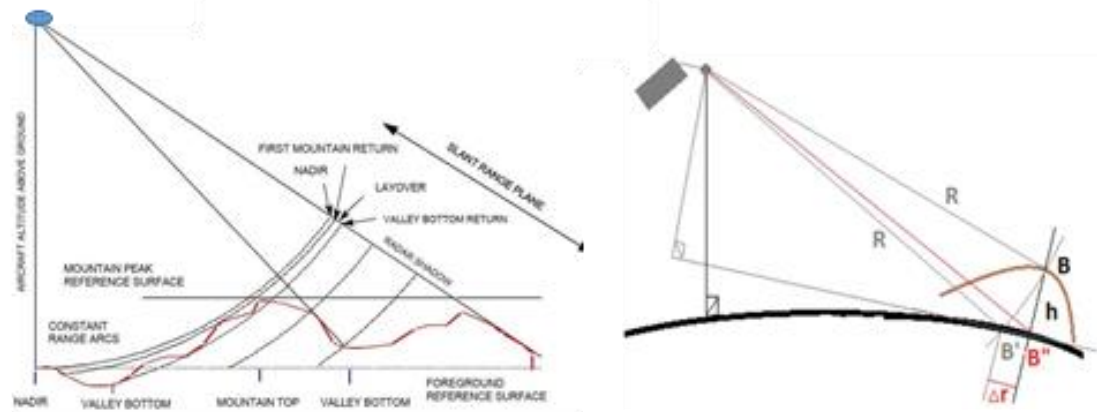
Level-1 Ground Range Detected (GRD) products consist of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model. Phase information is lost. For more info :

<https://sentinel.esa.int/web/sentinel/missions/sentinel-1/data-products>



## PART II : Data Navigation and Preprocess

GRD Images  
projected onto  
reference ellipsoide  
(no topography)



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



## 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>

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

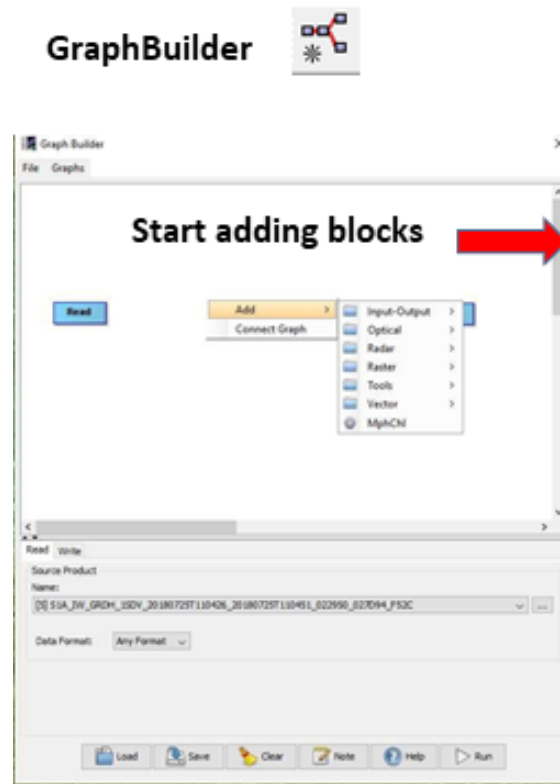
As they must be applied to a collection of GRD images, we use to define a general **pre- processing graph**



To be later passed to the **Batch Processing Tool**



## PART II : Data Navigation and Preprocess



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**)

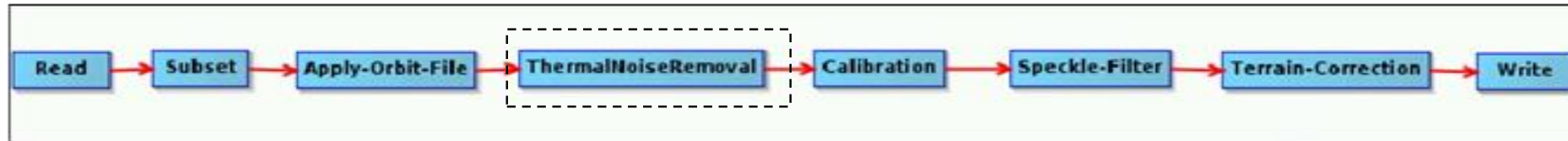
Speckle filtering (**Radar -> Speckle Filtering -> Speckle-Filter**)

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 ->**

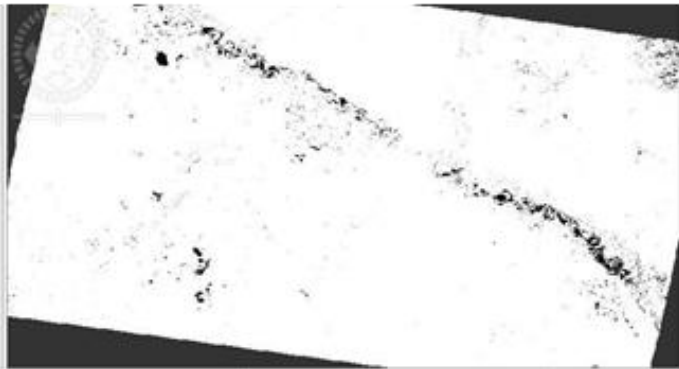
- **Tile Evenly**

Select the **Sigma0\_VV** band corresponding to April 18<sup>th</sup> capture to activate it



- Select the Color Manipulation tab and click the Stretch Histogram Horizontally  and then the logarithmic display **Log<sub>10</sub>**

- Move the max, middle and minimum sliders around 0.023,0.015 and 0.009 on the histogram.



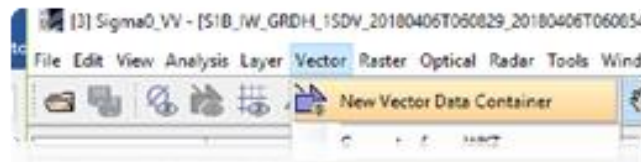
## PART III : Image Analysis and Water Mask Generation

---

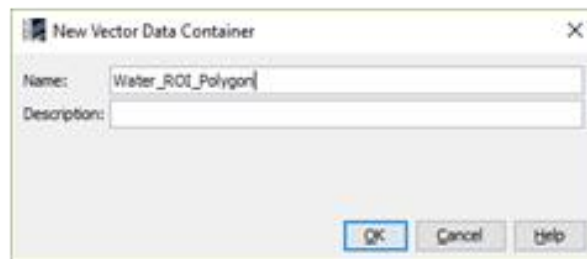
A binary mask of water and non-water pixels with a thresholding condition.


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)

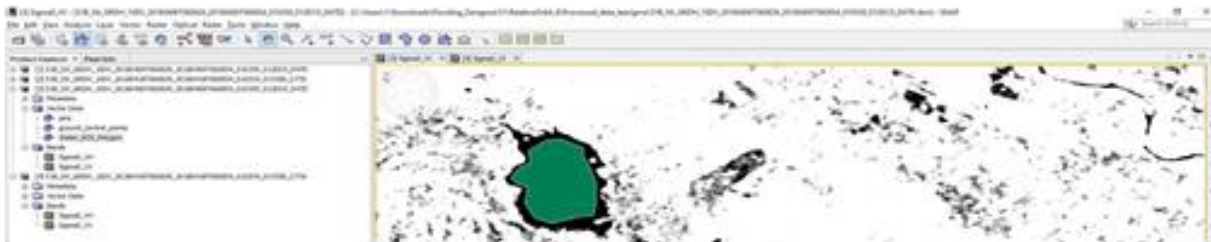


- Define Tool for ROI construction (Polygons Drawing Tool) 

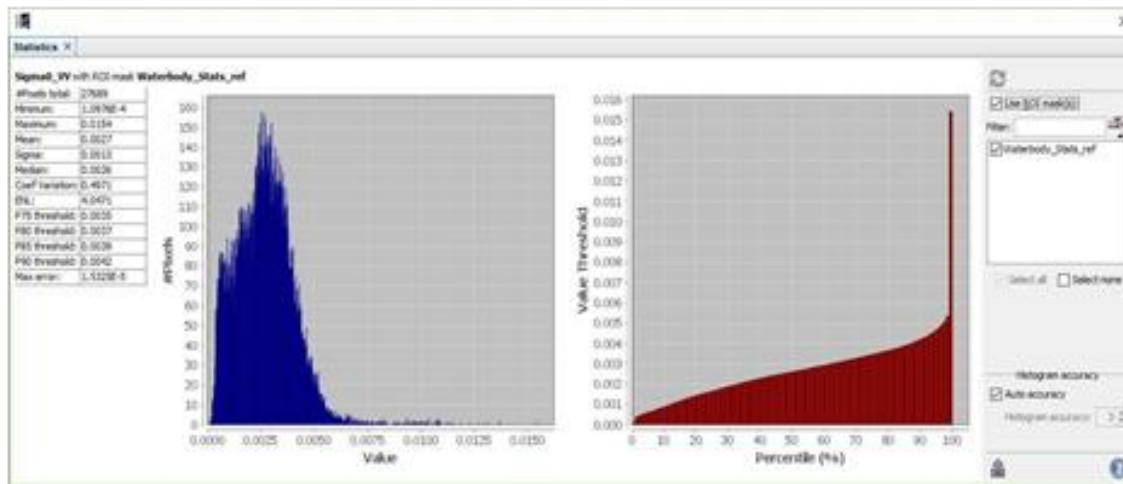


## PART III : Image Analysis and Water Mask Generation

- Draw polygon and double-click to close it



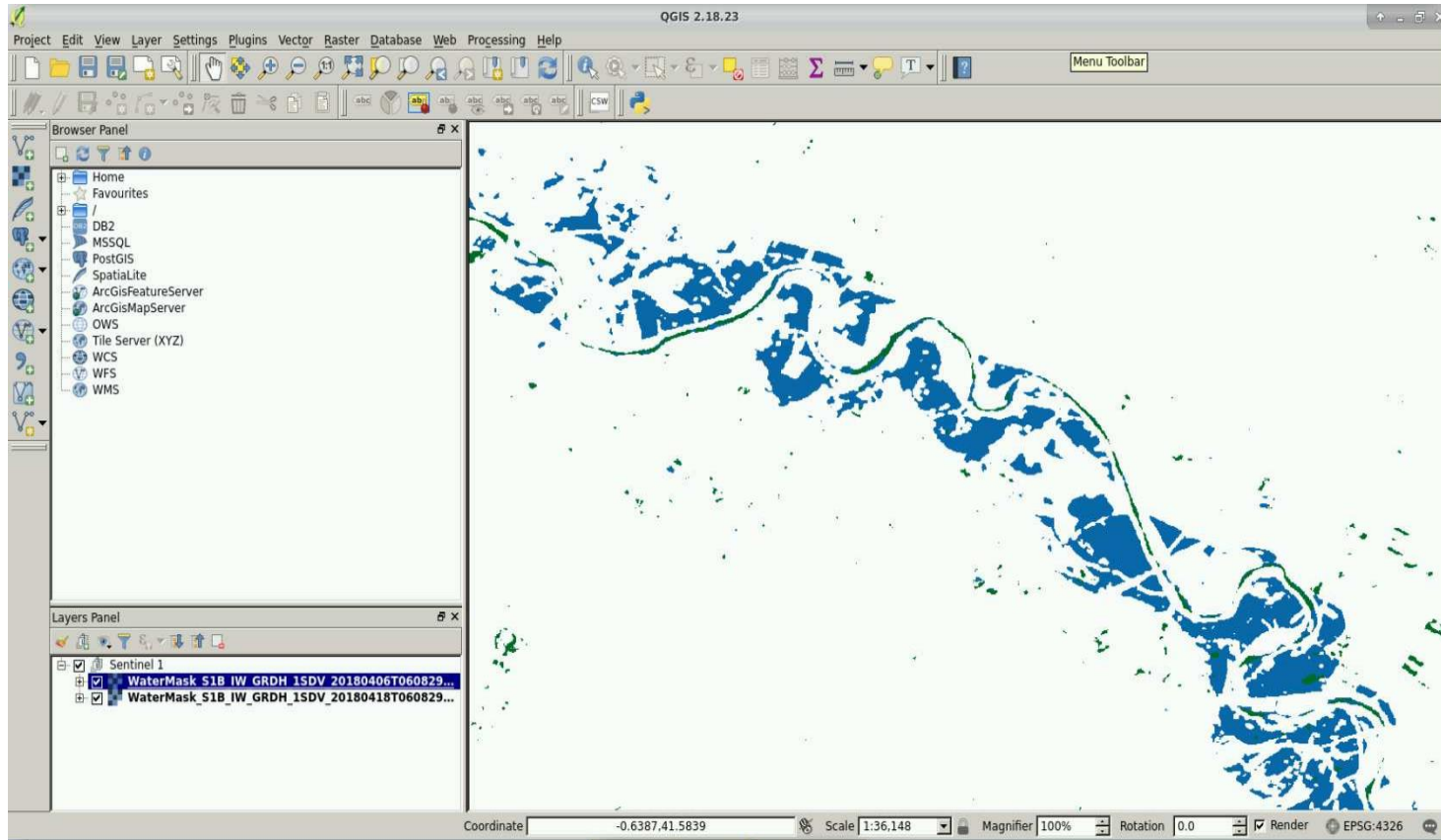
- Highlight Sigma0\_VV layer (where ROI is defined), then go to **Analysis->Statistics**, select **Use Roi Mask** and **Water\_ROI\_Polygon**.



- 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