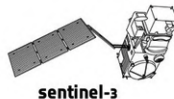
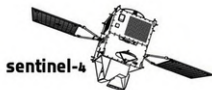
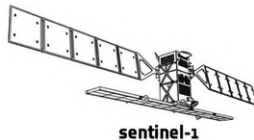


# Remote Sensing: brief overview

Alessandro Sebastianelli

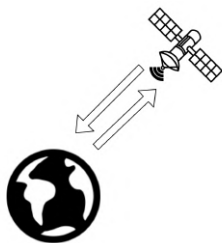
May 2022

# Copernicus and its Sentinels



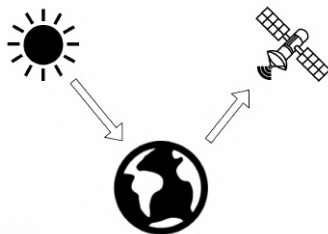
# Active vs Passive Sensors

Active Sensor



Sentinel-1  
Sentinel-3

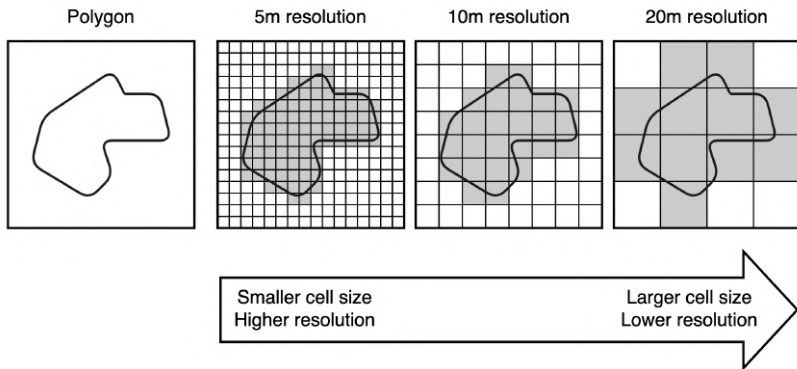
Passive Sensor



Sentinel-2  
Sentinel-5p

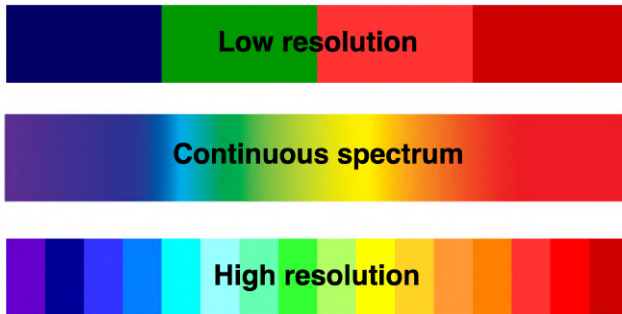
## Resolutions (1)

**Spatial Resolution:** it represents the smallest possible feature that can be detected. The spatial resolution quantifies the capability to separate two close targets. The pixel size is often considered as spatial resolution. It depends on the design of the sensor, while the pixel size depends on the digital sampling of the signal.



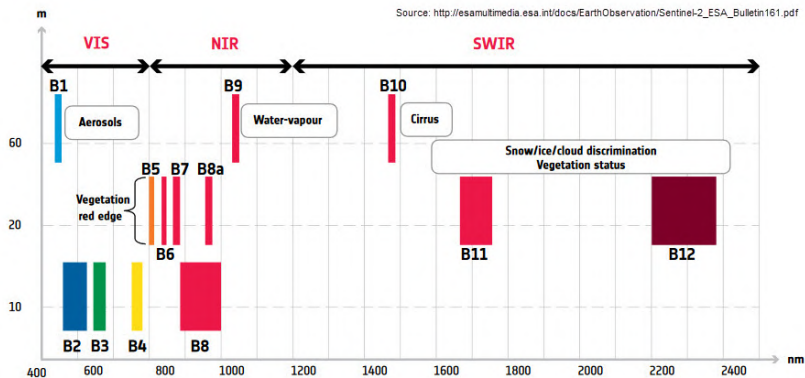
## Resolutions (2)

**Spectral Resolution:** it represents the wavelength of the different frequency bands recorded. Spectral resolution describes the ability of a sensor to define fine wavelength intervals.



## Resolutions (2)

**Spectral Resolution:** it represents the wavelength of the different frequency bands recorded. Spectral resolution describes the ability of a sensor to define fine wavelength intervals.



↑ Spatial resolution versus wavelength: Sentinel-2's span of 13 spectral bands, from the visible and the near-infrared to the shortwave infrared at different spatial resolutions ranging from 10 to 60 m on the ground, takes land monitoring to an unprecedented level

## Resolutions (3)

**Radiometric Resolution:** it refers to the number of different intensities of radiation the sensor is able to distinguish. The greater the radiometric resolution, the more accurate the sensed image will be.

8-bit radiance level

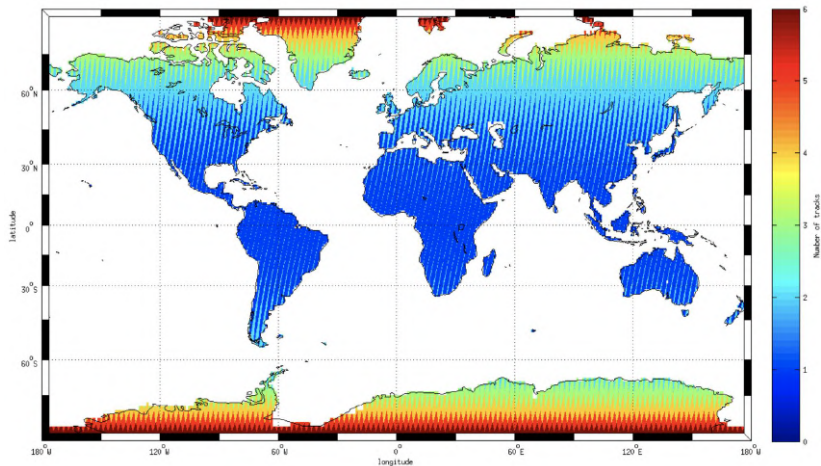


2-bit radiance level



## Resolutions (4)

**Temporal Resolution:** is the frequency of flyovers by the satellite. This resolution can become relevant in time series studies or those requiring an averaged or mosaic image (e.g. change detection, deforestation monitoring)







Open Hub

# Copernicus Open Access Hub

<https://scihub.copernicus.eu/dhus/#/home>

# Main Page



# Set parameters

The screenshot shows the 'Advanced Search' interface of the Copernicus Data Explorer. The interface is divided into two main sections for Sentinel-1 and Sentinel-2 missions. The Sentinel-1 section is currently selected and highlighted with a blue border. The Sentinel-2 section is visible below it but is not selected.

**Sentinel-1 Search Parameters:**

- Sort By:** Ingestion Date
- Order By:** Descending
- Sensing period:** 2019/04/01 to 2019/10/30
- Ingestion period:** (empty)
- Mission:** Sentinel-1 (selected)
- Satellite Platform:** S1A\_\*
- Polarisation:** (empty)
- Relative Orbit Number (from 1 to 175):** (empty)
- Product Type:** SLC
- Sensor Mode:** IW
- Collection:** (empty)

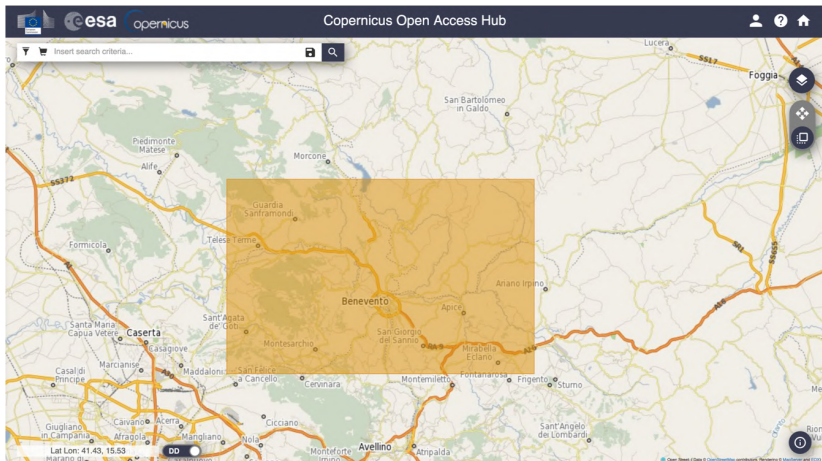
**Sentinel-2 Search Parameters:**

- Mission:** Sentinel-2 (not selected)
- Satellite Platform:** (empty)
- Relative Orbit Number (from 1 to 175):** (empty)
- Product Type:** (empty)
- Cloud Cover % (e.g. [0 TO 9.4]):** (empty)

The interface also includes a search bar at the top with the text 'Insert search criteria...', a 'Clear' button, and a map view on the right side showing the location of the search area.

- Mission
- Platform
- Sensing Period (start and end date)
- Product type
- Acquisition mode

# Select the AOI (Area Of Interest) (1)



## Select the AOI (Area Of Interest) (2)

The screenshot displays the Copernicus Open Access Hub interface. On the right, a map of Italy shows a red polygon representing the Area of Interest (AOI) over the central and southern regions. On the left, a search results panel shows a list of products. The first product is highlighted.

**Copernicus Open Access Hub**

Insert search criteria...

Display 1 to 25 of 90 products.  
Order By: Ingestion Date ↓

0 products selected

**Request Done:** ( footprint:Intersects(POLYGON((14.465271252979884  
41.02902484719749,15.068734527799604  
41.02902484719749,15.068734527799604  
...)) )

Product ID	Download URL	Mission	Instrument	Sensing Date
<b>S1A</b>   <b>SAR-C</b>   S1A_IW_SLC__1SDV_20191030T165730_20191030T165757_029691_...	<a href="https://isohub.copernicus.eu/odata/v1/Products/20860480">https://isohub.copernicus.eu/odata/v1/Products/20860480</a>	Sentinel-1	SAR-C	2019-10-30T16:57:30.63Z
<b>S1A</b>   <b>SAR-C</b>   S1A_IW_SLC__1SDV_20191030T165704_20191030T165732_029691_...	<a href="https://isohub.copernicus.eu/odata/v1/Products/20107174">https://isohub.copernicus.eu/odata/v1/Products/20107174</a>	Sentinel-1	SAR-C	2019-10-30T16:57:04.84Z
<b>S1A</b>   <b>SAR-C</b>   S1A_IW_SLC__1SDV_20191029T051206_20191029T051234_029668_...	<a href="https://isohub.copernicus.eu/odata/v1/Products/42033004">https://isohub.copernicus.eu/odata/v1/Products/42033004</a>	Sentinel-1	SAR-C	2019-10-29T05:12:06.43Z
<b>S1A</b>   <b>SAR-C</b>   S1A_IW_SLC__1SDV_20191024T050340_20191024T050408_029596_...	<a href="https://isohub.copernicus.eu/odata/v1/Products/41560360">https://isohub.copernicus.eu/odata/v1/Products/41560360</a>	Sentinel-1	SAR-C	2019-10-24T05:03:40.75Z
<b>S1A</b>   <b>SAR-C</b>   S1A_IW_SLC__1SDV_20191024T050406_20191024T050433_029596_...	<a href="https://isohub.copernicus.eu/odata/v1/Products/40180636">https://isohub.copernicus.eu/odata/v1/Products/40180636</a>	Sentinel-1	SAR-C	2019-10-24T05:04:33.21Z

25 of 90 products | page: 1 of 4 | << >>



# Alaska Satellite Facility

<https://search.asf.alaska.edu/#/>

# Main Page

**ASF Data Search Vertex**

Search Type: Geographic Dataset: Sentinel-1 Area of Interest: WKT Filters: 250 of 10,571,756 Files

SEARCH

Downloads Sign in

Map Projection: Zoom View Area of Interest Selection Strings

lat: 73.3402° lon: -33.6054°

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# Set parameters

The screenshot displays the ASF Data Search Vertex web application. The interface is divided into several sections:

- Header:** Includes the ASF Data Search Vertex logo, a search type dropdown set to "Geographic", and a start date of "Jan 01 2015". On the right, there are icons for Downloads, Sign in, and a menu.
- Search Filters Panel:**
  - Date Filters:** Features "Start Date" (1/1/2019) and "End Date" (4/30/2019) with calendar icons. Below is a "Seasonal Search" toggle switch.
  - Additional Filters:** Contains four dropdown menus: "File Type" (L1 Single Look Comp...), "Beam Mode" (IW), "Polarization" (Ascending), and "Direction" (Ascending). Below these, it shows selection counts: "1/14 file types selected", "1/9 beam modes selected", "0/8 polarizations selected", and "1/2 flight directions selected". A "Subtype" dropdown shows "0/2 subtypes selected".
  - Path and Frame Filters:** Includes input fields for "Path Start", "Path End", "Frame Start", and "Frame End", along with a "Clear" button.
- Map:** A satellite map of Europe and North Africa is shown on the left and right. A "Click to start drawing" button is visible on the map. A NASA logo is in the bottom right corner of the map area.
- Footer:** At the bottom, it shows "250 of 48,197 Files" and a "SEARCH" button. The bottom left corner credits "MapTiler" and "OpenStreetMap contributors". The bottom right corner includes "© 2020 ASF | Contact | Non-Discrimination".



# Select the AOI (Area Of Interest)

**ASF Data Search Vertex**

Search Type: Geographic Dataset: Sentinel-1 Area of Interest - WKT: POLYGON((13.9295 41.4C) Filters: 250 of 118 Files

Start: Jan 01 2019 End: Apr 30 2019 File Types: SLC Beam Modes: IW Flight Dir: Ascending

Map Projection: Zoom View Area of Interest Selection Shapes

lat: 42.1019° lon: 18.5882°

118 Scenes (118 of 118 Files)

Scene Detail	1 File
<p><b>S1A_IW_SLC__1SDV_20190428T1649... 7038</b> April 28 2019 16:49:12</p> <p><b>S1A_IW_SLC__1SDV_20190428T1648... 5412</b> April 28 2019 16:48:47</p> <p><b>S1B_IW_SLC__1SDV_20190427T1656... FFE9</b> April 27 2019 16:56:38</p> <p><b>S1B_IW_SLC__1SDV_20190427T1656... 196C</b> April 27 2019 16:56:13</p> <p><b>S1A_IW_SLC__1SDV_20190426T1705... EF33</b></p>	<p><b>S1A_IW_SLC__1SDV_20190428T164912_20190428T164939_026993_0309EC_7038</b> Sentinel-1 - C-Band</p> <p>Start Time: 04/28/19, 16:49:12 Beam Mode: IW Path: 146 Frame: 133 Flight Direction: ASCENDING Polarisation: VV-VH Absolute Orbit: 25993 Data courtesy of ESA</p> <p>L1 Single Look Complex (SLC) 3.52 GB</p>

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Baseline Tool Citation More Like This

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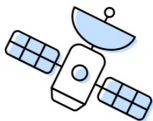


# Google Earth Engine

<https://code.earthengine.google.com/>

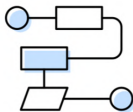
# Google Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use Earth Engine to detect changes, map trends, and quantify differences on the Earth's surface. Earth Engine is now available for commercial use, and remains free for academic and research use.



Satellite Imagery

+



Your Algorithms

+



Real World Applications

# Main Page

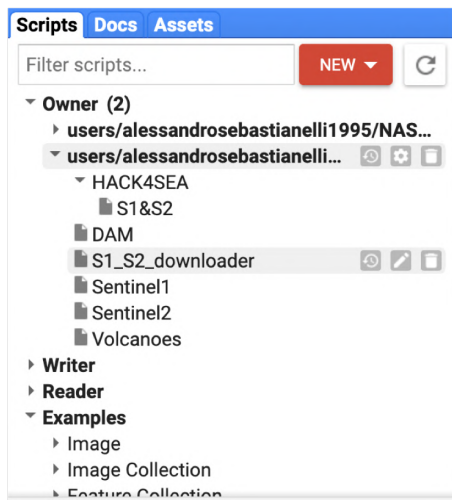
The screenshot displays the Google Earth Engine web interface. At the top, the 'Google Earth Engine' logo is on the left, and a search bar with the placeholder text 'Search places and datasets...' is in the center. To the right of the search bar are icons for help, notifications, and a user profile.

Below the header, the interface is divided into several sections:

- Left Panel:** Contains tabs for 'Scripts', 'Docs', and 'Assets'. Under 'Scripts', there is a 'Filter scripts...' input field, a 'NEW' button, and a refresh icon. A list of scripts is shown, including 'Owner (2)', 'Writer', 'Reader', and 'Examples' (with sub-items like 'Image', 'Image Collection', 'Feature Collection', 'Charts', and 'Arrays').
- Center Panel:** Titled 'New Script', it includes buttons for 'Get Link', 'Save', 'Run', 'Reset', and 'App'. Below these buttons is a script editor with a line of code: `1`.
- Right Panel:** Contains tabs for 'Inspector', 'Console', and 'Tasks'. The 'Console' tab is active, displaying a message: 'Use print(...) to write to this console.' Below this, a warning message states: 'Attention Python and JavaScript client library users! Earth Engine servers now require client library v0.1.215, released March 11. Please update to the latest Python or JavaScript version to avoid a break in service.'
- Map View:** The bottom half of the interface shows a map of North America, specifically focusing on the United States and Mexico. The map includes labels for various states and countries, as well as major cities like San Francisco, Los Angeles, San Diego, Dallas, Houston, Chicago, and New York. The map is zoomed in on the central United States.

At the bottom of the map view, there is a scale bar indicating '500 km' and a link to 'Termini e condizioni d'uso'.

# GEE Components (1)



## Scripts

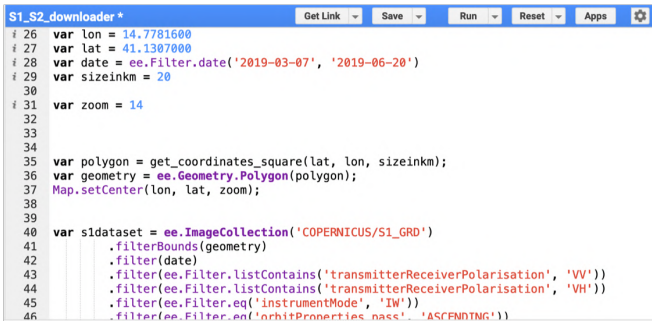
- ▶ Examples
- ▶ User code

## Docs

- ▶ Code documentation

## GEE Components (2)

The **code editor** allows to write and execute GEE code. GEE is based on Javascript, adapted properly to the platform. There exists also a Python API with the same functionalities, but it can be used only outside the web app.

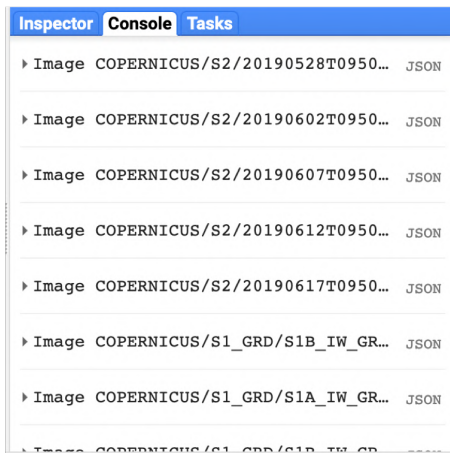


The screenshot shows the GEE code editor interface. At the top, there is a blue header bar with the text "S1\_S2\_downloader \*" and several buttons: "Get Link", "Save", "Run", "Reset", "Apps", and a settings gear icon. Below the header, the code editor displays a JavaScript script for downloading Sentinel-1 data. The script includes comments (lines starting with #) and code for setting variables like longitude, latitude, date range, size in km, and zoom. It then defines a polygon, sets the map center, and creates an image collection filtered by various parameters including transmitter/receiver polarisation and instrument mode.

```

# 26 var lon = 14.7781600
# 27 var lat = 41.1307000
# 28 var date = ee.Filter.date('2019-03-07', '2019-06-20')
# 29 var sizeinkm = 20
# 30
# 31 var zoom = 14
# 32
# 33
# 34
35 var polygon = get_coordinates_square(lat, lon, sizeinkm);
36 var geometry = ee.Geometry.Polygon(polygon);
37 Map.setCenter(lon, lat, zoom);
38
39
40 var s1dataset = ee.ImageCollection('COPERNICUS/S1_GRD')
41   .filterBounds(geometry)
42   .filter(date)
43   .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VV'))
44   .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VH'))
45   .filter(ee.Filter.eq('instrumentMode', 'IW'))
46   .filter(ee.Filter.eq('orbitProperties_pass', 'ASCENDING'))
  
```

# GEE Components (3)



## Console

- Terminal used to monitor activities, to print variables and to debug code

## Tasks

- It allows to monitor or to start tasks (e.g. download data)

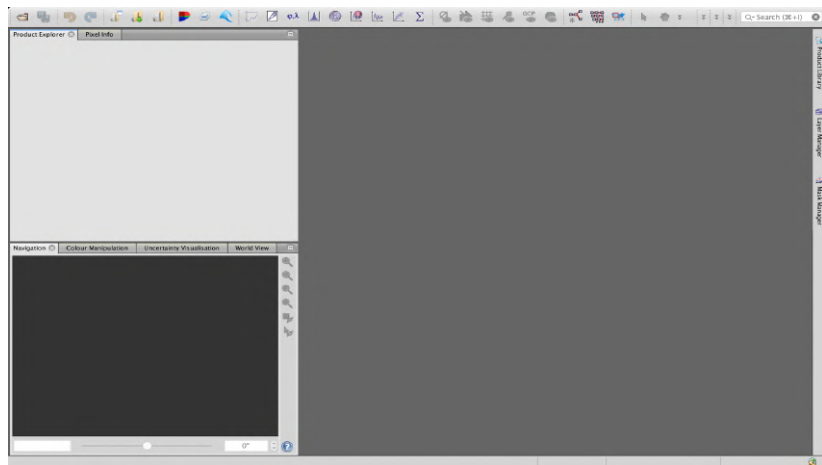


# Sentinel Application Platform

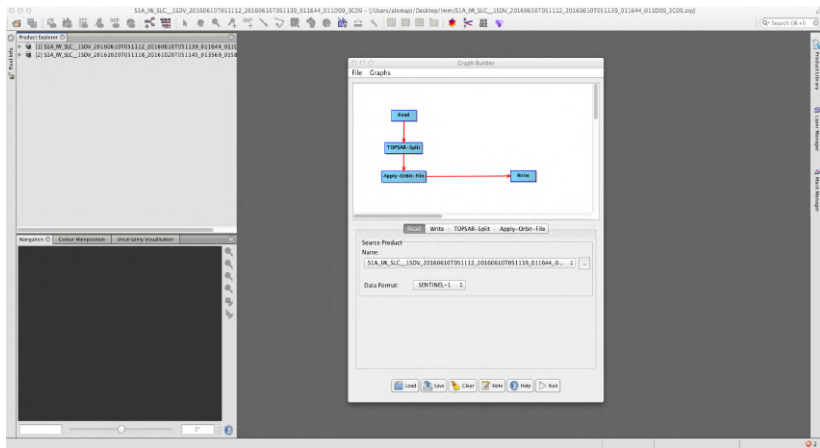
<https://step.esa.int/main/download/>

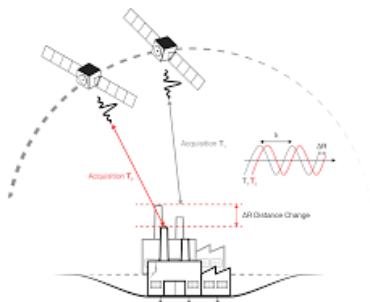


# Main Page



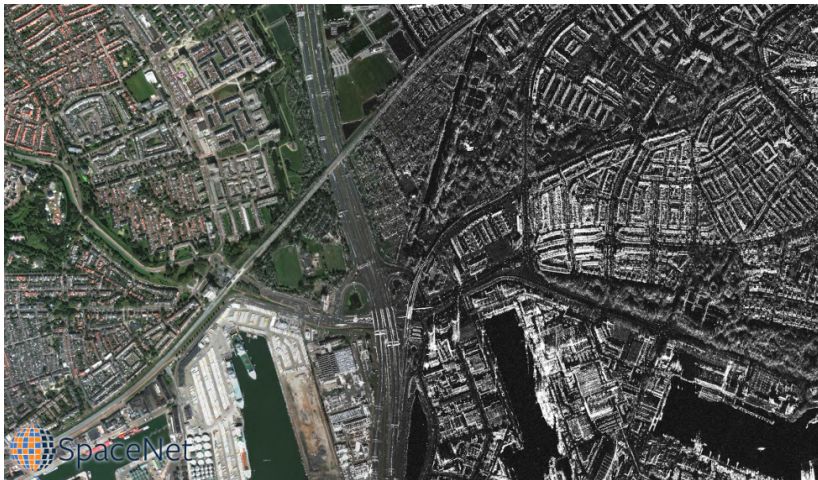
# Use functions



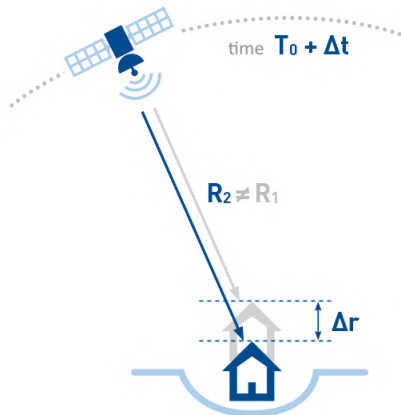


# DInSAR: Differential Interferometric Synthetic Aperture Radar

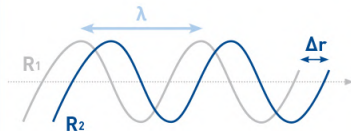
# SAR vs Optical



# DInSAR (1)



## INTERFEROMETRY



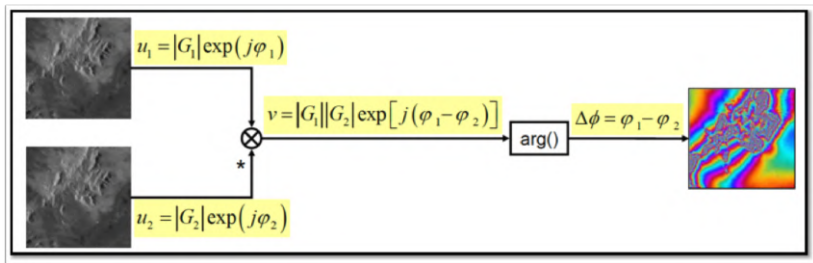
$\lambda$  - wavelength:

C-band = 5.66 [cm]

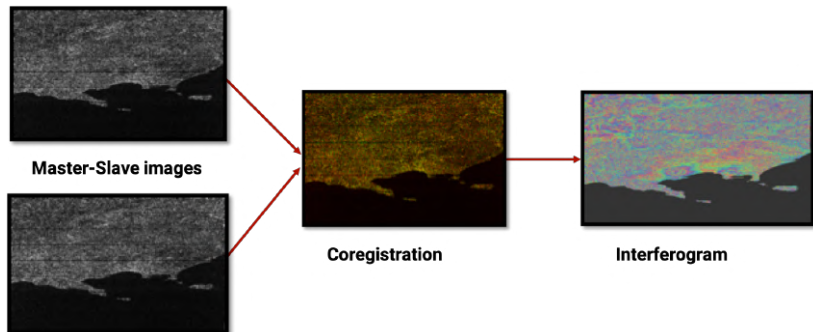
X-band = 3.10 [cm]

L-band = 24.00 [cm]

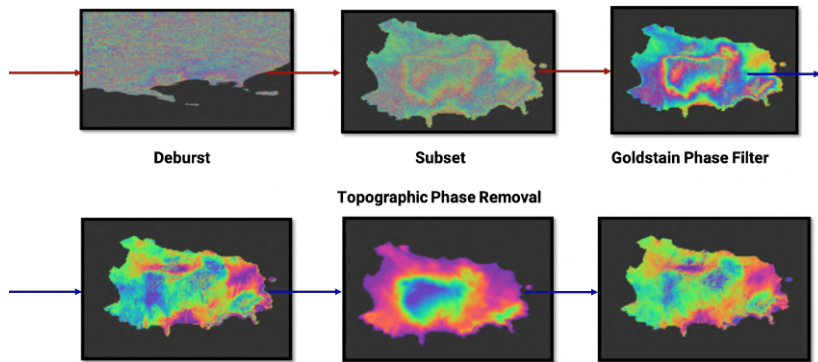
## DInSAR (2)



## DInSAR (3)

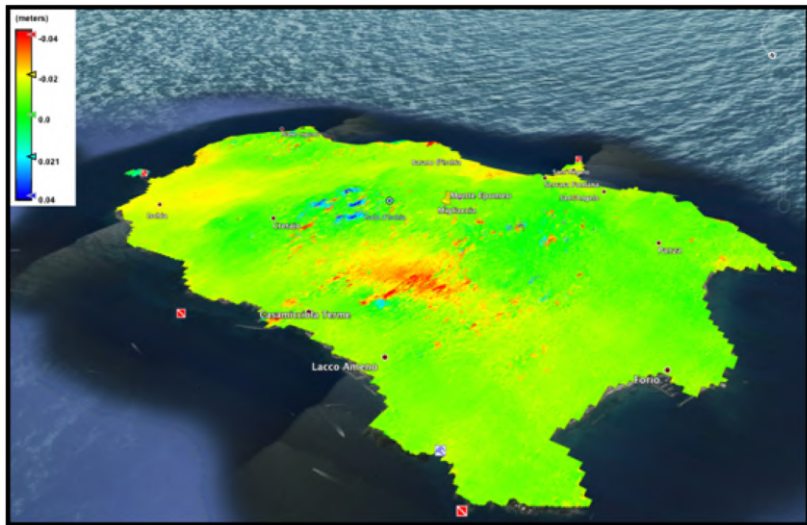


# DInSAR (4)





## DInSAR (5)



# Assignments

# Assignment 1

- ▶ Register on Open Access Hub
- ▶ Download a Sentinel-2 image
- ▶ Open the image on SNAP or on QGIS

## Assignment 2

- ▶ Register on Google Earth Engine
- ▶ Copy the code at  
`https://github.com/Sebbyraft/GoogleEarthEngine/blob/master/sentinel\_1\_and\_2\_downloader.js`
- ▶ Paste the code in a new script on GEE
- ▶ Save the script and run it
- ▶ Change size in Km to change the size of the image
- ▶ Change the date
- ▶ Change lat and lon to change the geographical position
- ▶ Start the tasks for 1 Sentinel-1 and 1 Sentinel-2 image
- ▶ Download the data from Google Drive
- ▶ Open the images in SNAP or QGIS