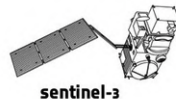
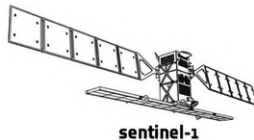
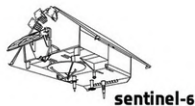
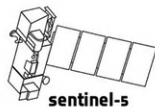


Remote Sensing: brief overview

Alessandro Sebastianelli

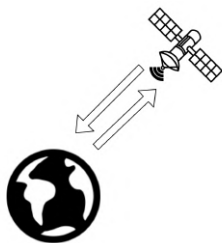
May 2022

Copernicus and its Sentinels



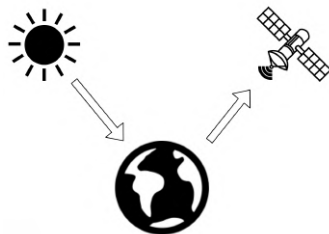
Active vs Passive Sensors

Active Sensor



Sentinel-1
Sentinel-3

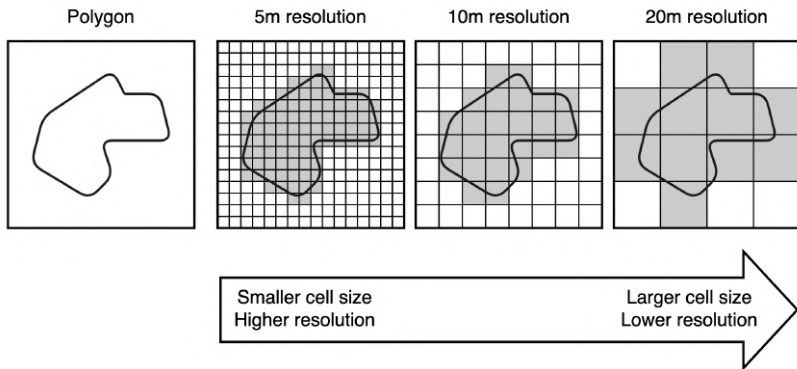
Passive Sensor



Sentinel-2
Sentinel-5p

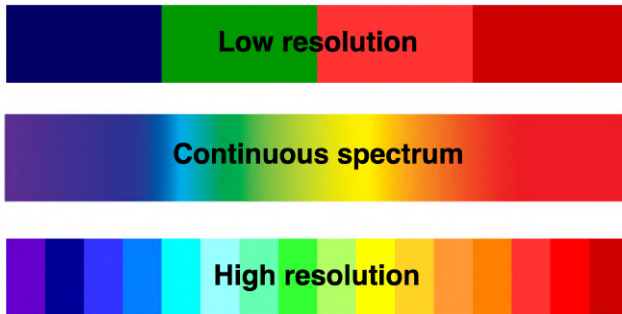
Resolutions (1)

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.



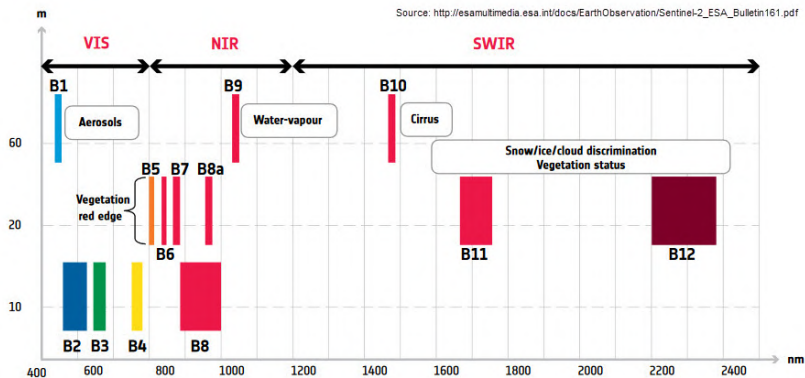
Resolutions (2)

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

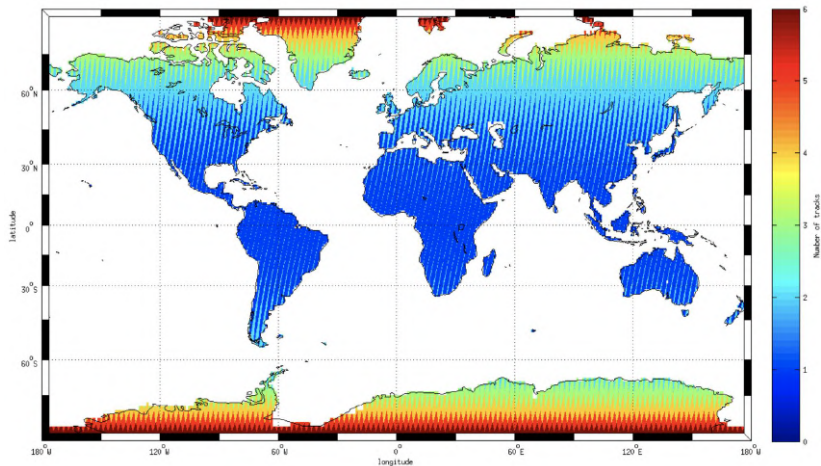


2-bit radiance level



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 portal. The interface is divided into two main sections for Sentinel-1 and Sentinel-2 missions. The Sentinel-1 section is currently selected and active.

Advanced Search (Clear)

» Sort By: Ingestion Date
» Order By: Descending

» Sensing period: 2019/04/01 to 2019/10/30

» Ingestion period: [Empty field]

☒ **Mission: Sentinel-1**

Satellite Platform: S1A_*
Polarisation: [Empty field]
Relative Orbit Number (from 1 to 175): [Empty field]

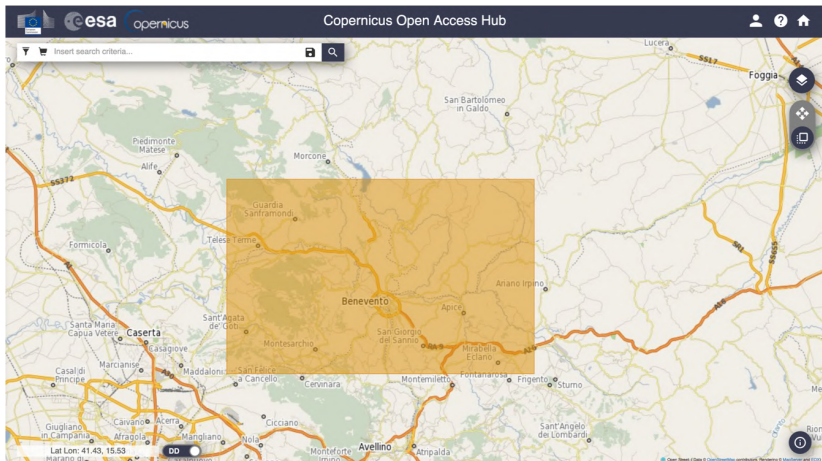
Product Type: SLC
Sensor Mode: IW
Collection: [Empty field]

☐ **Mission: Sentinel-2**

Satellite Platform: [Empty field]
Relative Orbit Number (from 1 to [Empty field]): [Empty field]
Product Type: [Empty field]
Cloud Cover % (e.g. [0 TO 9.4]): [Empty field]

- 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.

Search Criteria: Insert search criteria...

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

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

Products List:

- S1A SAR-C** S1A_IW_SLC__1SDV_20191030T165730_20191030T165757_029691...
Download URL: <https://isohub.copernicus.eu/odata/v1/Products/20860480>
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2019-10-30T16:57:30.63Z
- S1A SAR-C** S1A_IW_SLC__1SDV_20191030T165704_20191030T165732_029691...
Download URL: <https://isohub.copernicus.eu/odata/v1/Products/20107170>
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2019-10-30T16:57:04.84Z
- S1A SAR-C** S1A_IW_SLC__1SDV_20191029T051206_20191029T051234_029668...
Download URL: <https://isohub.copernicus.eu/odata/v1/Products/40393300>
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2019-10-29T05:12:06.43Z
- S1A SAR-C** S1A_IW_SLC__1SDV_20191024T050340_20191024T050408_029596...
Download URL: <https://isohub.copernicus.eu/odata/v1/Products/41560360>
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2019-10-24T05:03:40.75Z
- S1A SAR-C** S1A_IW_SLC__1SDV_20191024T050406_20191024T050433_029596...
Download URL: <https://isohub.copernicus.eu/odata/v1/Products/40180636>
Mission: Sentinel-1 Instrument: SAR-C Sensing Date: 2019-10-24T05:04:06.21Z

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:

- Top Bar:** 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:** Shows a date range from "1/1/2019" to "4/30/2019". A "Seasonal Search" toggle is present.
 - Additional Filters:**
 - File Type:** Set to "L1 Single Look Comp...".
 - Beam Mode:** Set to "IW".
 - Polarization:** Set to "Ascending".
 - Direction:** Set to "Ascending".
 - Summary: 1/14 file types selected, 1/9 beam modes selected, 0/8 polarizations selected, 1/2 flight directions selected.
 - Subtype:** Set to "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. 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:** Shows "250 of 48,197 Files" and a "SEARCH" button.

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>S1A_IW_SLC__1SDV_20190428T1649... 7038 April 28 2019 16:49:12</p> <p>S1A_IW_SLC__1SDV_20190428T1648... 5412 April 28 2019 16:48:47</p> <p>S1B_IW_SLC__1SDV_20190427T1656... FFE9 April 27 2019 16:56:38</p> <p>S1B_IW_SLC__1SDV_20190427T1656... 196C April 27 2019 16:56:13</p> <p>S1A_IW_SLC__1SDV_20190426T1705... EF33</p>	<p>S1A_IW_SLC__1SDV_20190428T164912_20190428T164939_026993_0309EC_7038 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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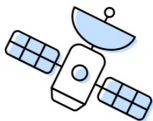


Google Earth Engine

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

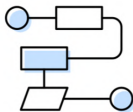
Google Earth Engine

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.

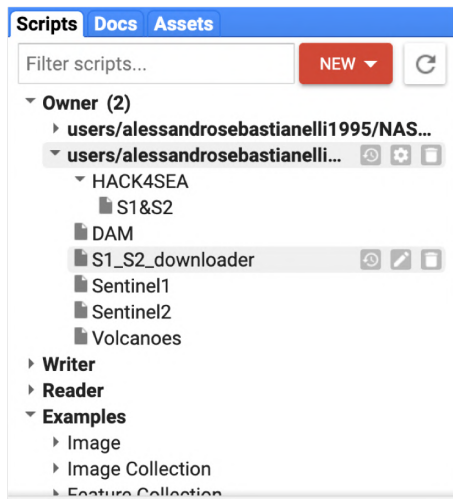
Below the search bar is a navigation bar with tabs for 'Scripts', 'Docs', and 'Assets'. The 'Scripts' tab is active, showing a 'Filter scripts...' section with a 'NEW' button and a refresh icon. A list of scripts is visible, including 'Owner (2)', 'Writer', 'Reader', and 'Examples' (with sub-items like 'Image', 'Image Collection', 'Feature Collection', 'Charts', and 'Arrays').

To the right of the script list is a 'New Script' panel with buttons for 'Get Link', 'Save', 'Run', 'Reset', and 'App'. Below these buttons is a code editor with a single line of code: '1'.

On the far right is the 'Inspector Console Tasks' panel. It contains a message: 'Use print(...) to write to this console.' Below this is a warning box titled 'Attention Python and JavaScript client library users!' which states: '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.'

The main area of the interface is a map of North America, showing the United States and parts of Canada and Mexico. The map is labeled with various states and provinces, including Washington, Oregon, California, Nevada, Utah, Arizona, New Mexico, Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, and others. Major cities like San Francisco, Los Angeles, San Diego, Dallas, Houston, Chicago, New York, and Montreal are marked. The map includes a scale bar (0 to 500 km) and a copyright notice: 'Dati mappa ©2020 Google, INEGI, IGN, NME'. A link to 'Termini e condizioni d'uso' is also present.

GEE Components (1)



Scripts

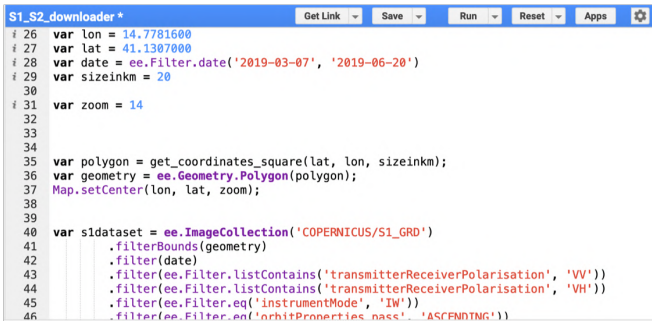
- ▶ Examples
- ▶ User code

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.

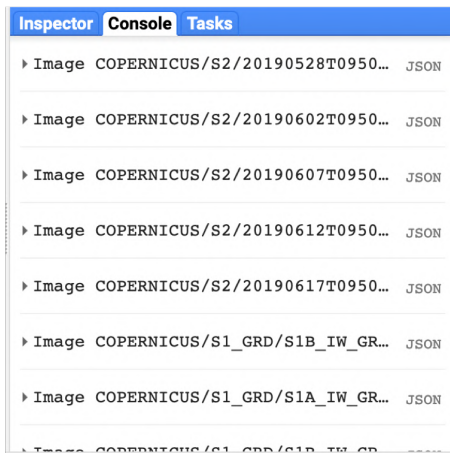


The screenshot shows the GEE code editor interface. At the top, there is a blue header bar with the text "S1_S2_downloader *" and several buttons: "Get Link", "Save", "Run", "Reset", "Apps", and a settings gear icon. Below the header, the code editor displays a JavaScript script for downloading Sentinel-1 data. The script includes comments (lines starting with #) and code for setting variables like longitude, latitude, date range, size in km, zoom, and polygon geometry. It then uses the GEE API to create an ImageCollection, filter it by date, transmitter/receiver polarisation, instrument mode, and orbit direction, and finally sets the center of the map.

```

# 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

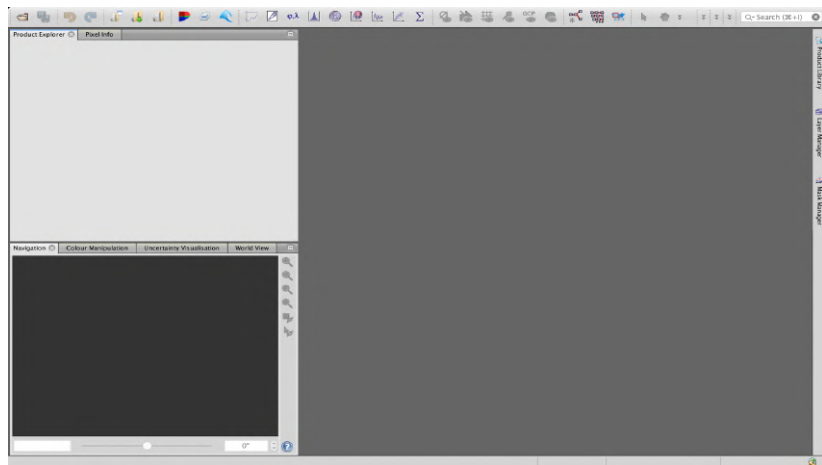
- It allows to monitor or to start tasks (e.g. download data)



Sentinel Application Platform

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

Main Page



Use functions

The screenshot displays a software application window titled "SIA_FW_SLC_1SDV_20160610T051112_20160610T051139_011644_011009_3C09.sig". The interface includes a "Product Explorer" on the left, a "Navigation" pane, and a "Graph Builder" window in the center.

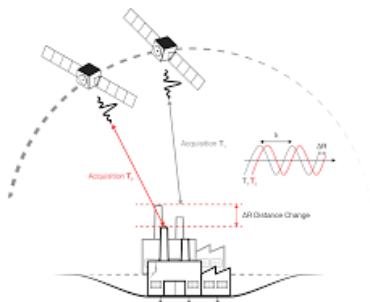
The "Graph Builder" window shows a flow diagram with the following steps:

```
graph TD; Read[Read] --> TOPSAR-Split[TOPSAR-Split]; TOPSAR-Split --> Apply-Orbit-File[Apply-Orbit-File]; Apply-Orbit-File --> Write[Write];
```

Below the diagram, the "Source Product" is configured with the following details:

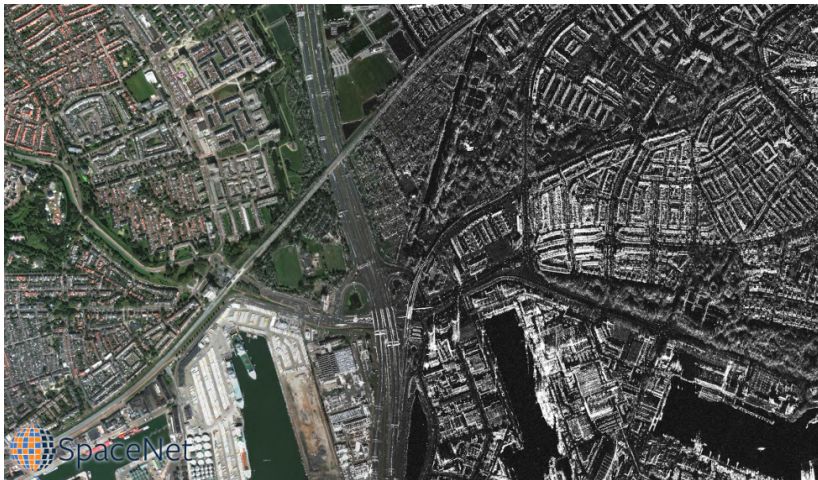
- Source Product Name: SIA_FW_SLC_1SDV_20160610T051112_20160610T051139_011644_0...
- Data Format: SENTINEL-1

At the bottom of the "Graph Builder" window, there are buttons for "Load", "Save", "Clear", "Help", and "Run".

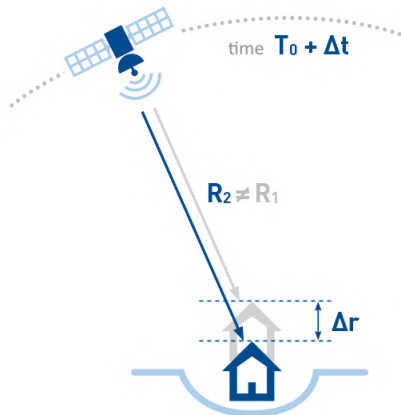


DInSAR: Differential Interferometric Synthetic Aperture Radar

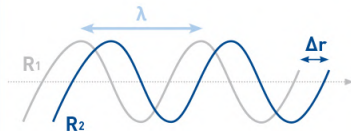
SAR vs Optical



DInSAR (1)



INTERFEROMETRY



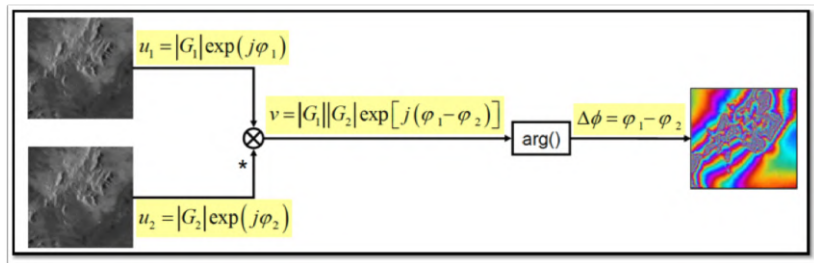
λ - wavelength:

C-band = 5.66 [cm]

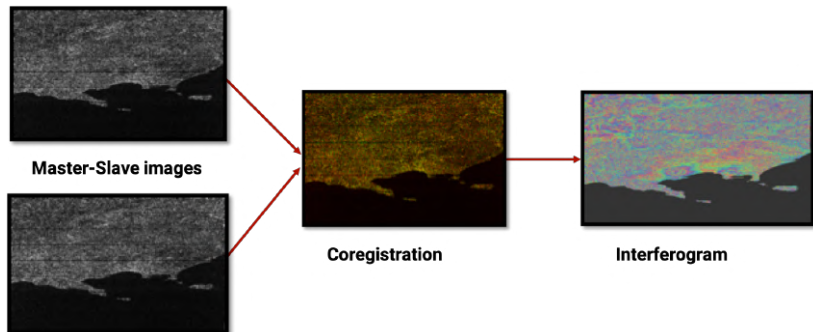
X-band = 3.10 [cm]

L-band = 24.00 [cm]

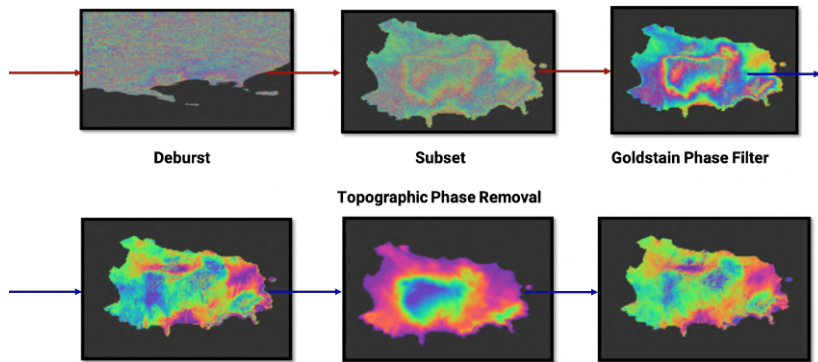
DInSAR (2)



DInSAR (3)



DInSAR (4)





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/AI4EO/blob/main/GEE-code/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