Damage assessment using SAR data (pixel-wise t-test)

Geoinformatics Center - AIT

Overview

Pixel-wise t-test is a statistical method used to detect significant changes in radar backscatter or coherence values between pre-event and post-event images at the pixel level.

Two SAR-based techniques are commonly used for damage mapping from satellite data:

1) Coherence change detection, comparing pre- and post-event SAR acquisitions.
2) Pixel-wise statistical testing (such as the t-test), to assess whether observed changes in coherence or backscatter are statistically significant.

In this tutorial, we will apply the pixel-wise t-test approach using Sentinel-1 data acquired before and after a GLOF event.

Overview

In this exercise, you will work with statistical methods applied to SAR imagery to assess damage. Specifically, we will perform a pixel-wise t-test on radar backscatter between pre-event and post-event images to identify significantly changed areas. The output will be exported and visualized using QGIS.

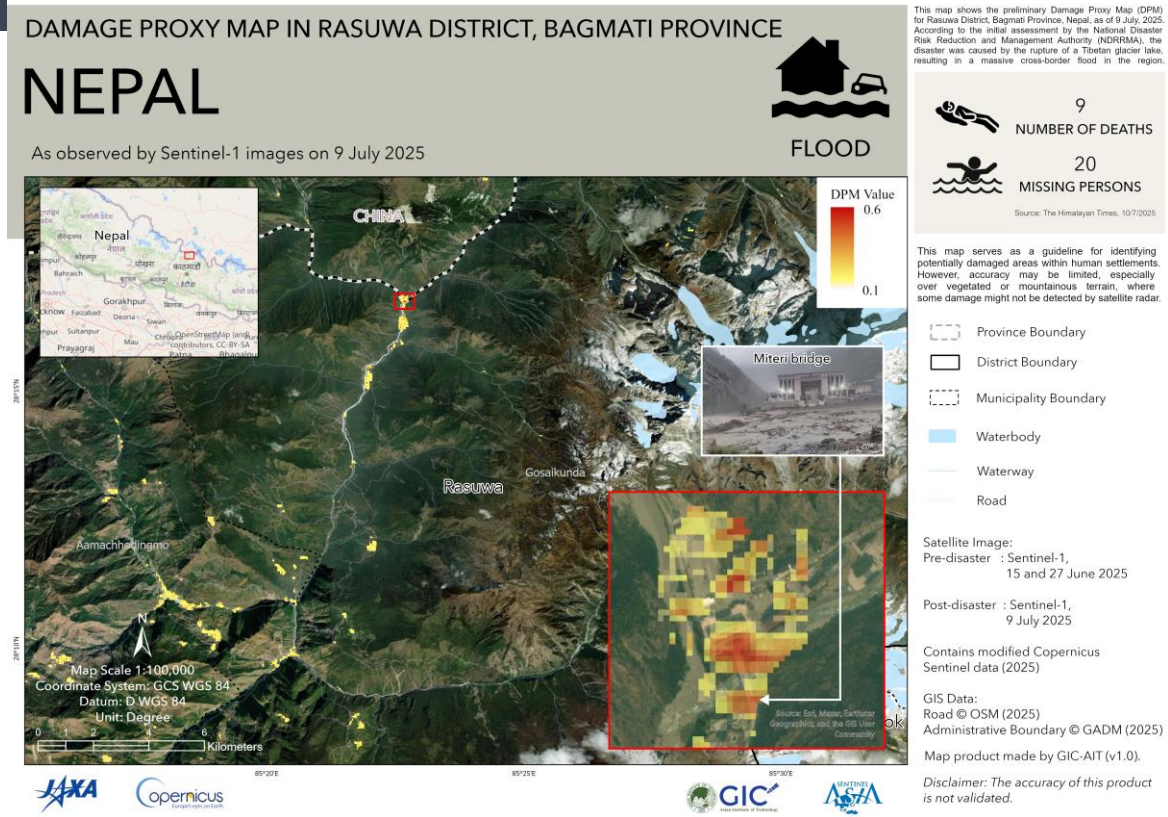
Data:

- Area of interest (AOI): defined by the earthquake extent

Coordinate	Meaning
85.299951	Minimum Longitude (West)
28.296120	Maximum Latitude (North)
85.398319	Maximum Longitude (East)
28.177378	Minimum Latitude (South)

- Event date: 8 July 2025 (GLOF in Nepal)

Overview



(https://sentinel-asia.org/EO/2025/article20250630NP.html)

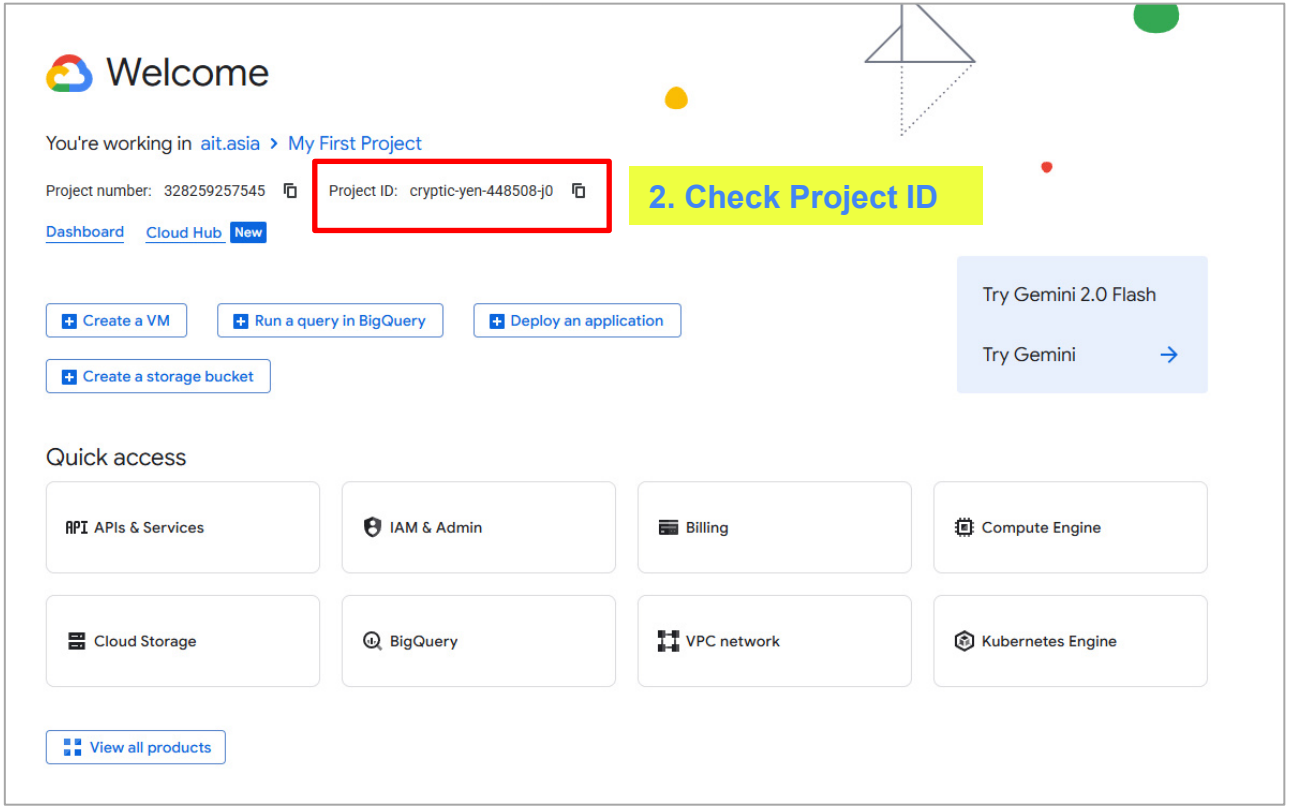
Sentinel Asia activation:

Flood in Nepal

- Occurrence Date (UTC): 30 June, 2025 and 08 July 2025
- SA activation Date(UTC): 01 July, 2025
- Requester: Department of Hydrology and Meteorology (DHM), Ministry of Energy, Water Resources and Irrigation

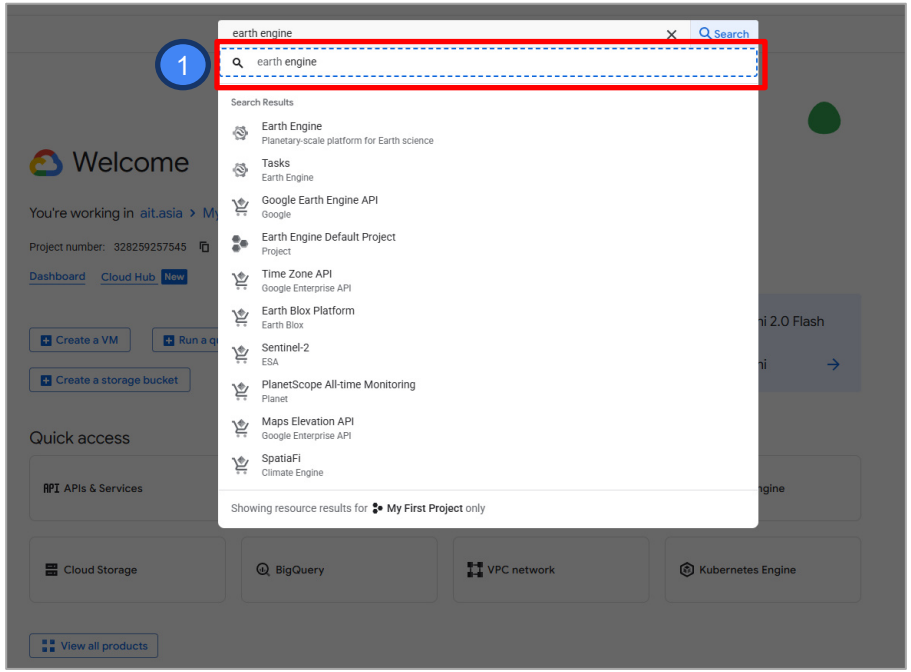
1. Check Google Earth Engine Project ID

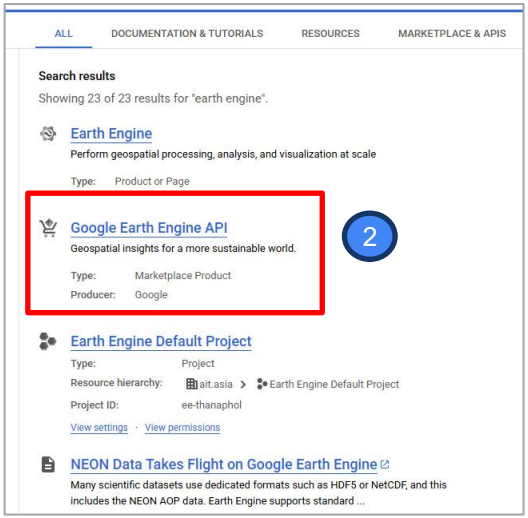
1. Go to This link: https://console.cloud.google.com/



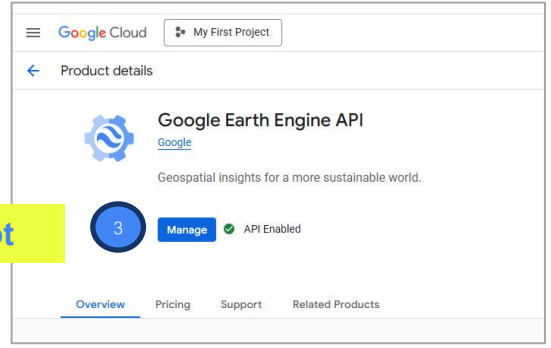
2. Check Google Earth Engine API

1. Search **Earth Engine**



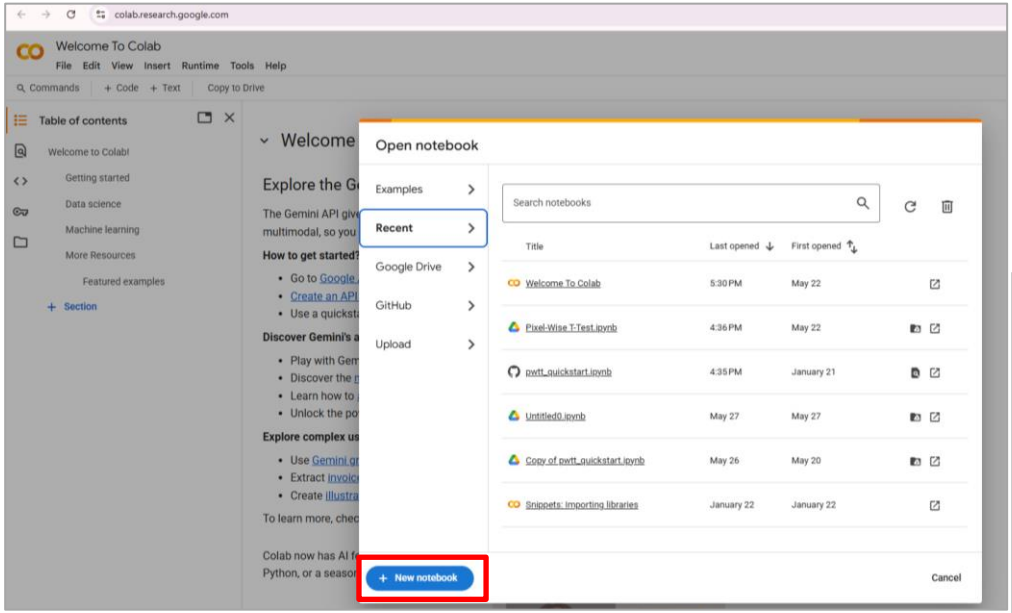


3. Check **API Enabled or not**

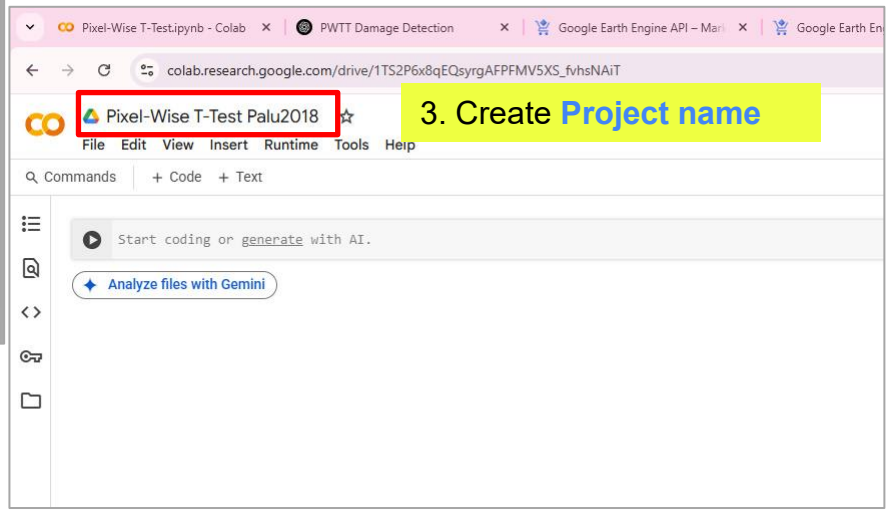


3. Open Google Colab

1. Go to This link: https://colab.research.google.com/



2. Create **New notebook**



3. Create **Project name**

4. Install and clone PWTT

- First, clone the repository and navigate to the code directory

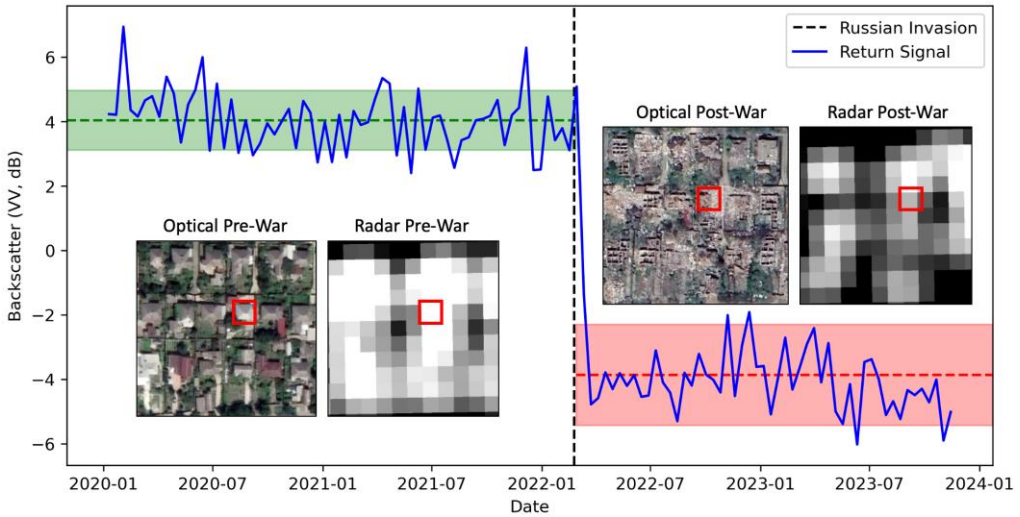
```
!git clone https://github.com/oballinger/PWTT
%cd PWTT/code
```

- Import required Python libraries

```
import ee
import pwtt
import geemap
```

Pixel-Wise T-Test (PWTT)

- A new algorithm for battle damage detection using Sentinel-1 SAR imagery
- Fast, lightweight, and generalizable
- PWTT compares mean radar backscatter before and after conflict.
- Applies a pixel-wise T-test to detect significant changes.
- T-score = (Mean_before - Mean_after) / Std_combined
- Advantages: No training needed, works on new areas, and low cost



(Ballinger, O. (2024). Open Access Battle Damage Detection via Pixel-Wise T-Test on Sentinel-1 Imagery.)

5. Authenticate and initialize GEE using a cloud project

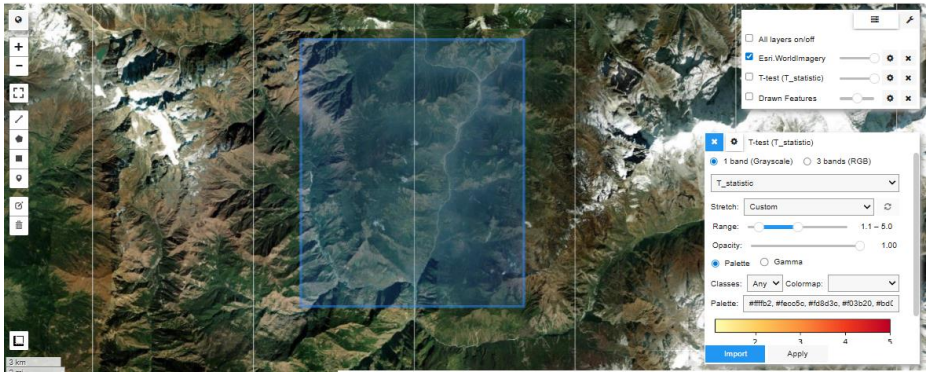
- First, clone the repository and navigate to the code directory

```
project_name = 'YOUR PROJECT NAME'
ee.Authenticate()
ee.Initialize(project=project_name)
```

6. Define Area of Interest (AOI)

- Set the geographic bounding box for Palu, Indonesia

```
gaza = ee.Geometry.Rectangle([85.299951, 28.296120,
85.398319, 28.177378])
```



Coordinate	Meaning
85.299951	Minimum Longitude (West)
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7. Time Parameters

- Define important temporal thresholds:

```
war_start = '2025-07-08'
inference_start = '2025-07-01'
pre_interval = 30
post_interval = 10
```

- war_start = Occurrence date of the earthquake (i.e., the date for selecting post-event images)
- inference_start = Start date of the pre-event observation period, used to select imagery before the earthquake
- pre_interval = Number of days before inference_start to define the full pre-event time window
- post_interval = Number of days after war_start to define the full post-event time window

8. Run PWTT

- Run PWTT to calculate T-statistics from Sentinel-1 time series:

```
result = pwtt.filter_s1(
    aoi=gaza,
    war_start=war_start,
    inference_start=inference_start,
    pre_interval=pre_interval,
    post_interval=post_interval,
    viz=False
)
```

9. Visualize T-score (T-statistic band)

- Optionally, adjust the minimum and maximum values or customize the color palette of the T-score image for better visualization.

```
t_score = result.select('T_statistic')
t_score_vis = {
    'min’: 0,
    'max’: 5,
    'palette': ['#ffffb2', '#fecc5c', '#fd8d3c', '#f03b20',
'#bd0026']  # Yellow to red
}
```

10. Display T-score map

- Display the T-score image over a satellite basemap for visual interpretation.

```
Map = geemap.Map(basemap='SATELLITE')
Map.centerObject(gaza, 12)
Map.addLayer(t_score, t_score_vis, 'T-test (T_statistic)')
display(Map)
```

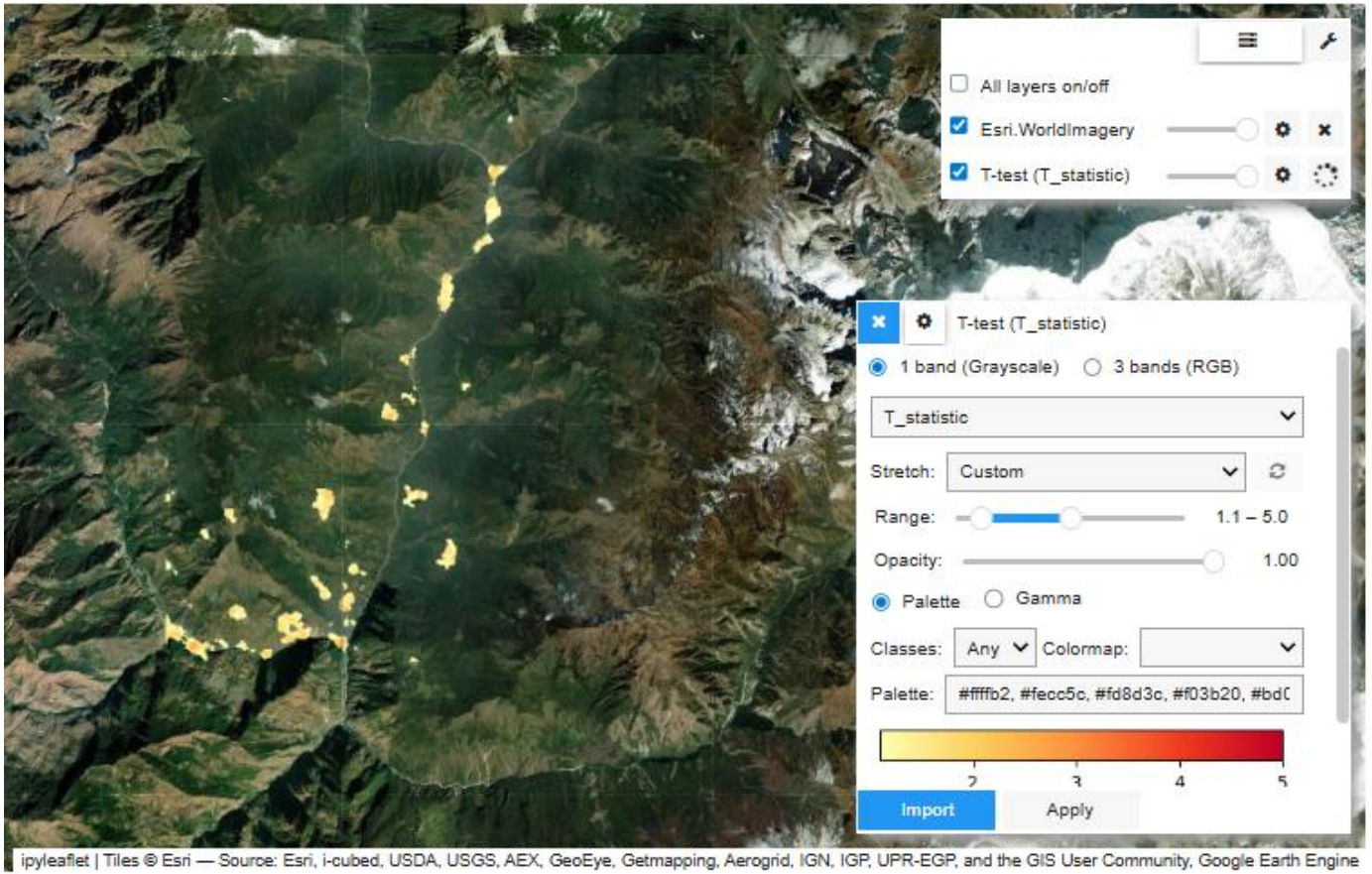
11. Export data

- Export T-score image to Google Drive as GeoTIFF

```
export_tscore_task = ee.batch.Export.image.toDrive(
    image=t_score.toFloat(),
    description='T_score_Export',
    folder='GEE_Exports',
    fileNamePrefix='t_score',
    region=gaza.bounds().getInfo()['coordinates'],
    scale=10,
    maxPixels=1e10
)
export_tscore_task.start()

print('Export started for T-score. Check your Google Drive folder "GEE_Exports" after the task finishes.')
```

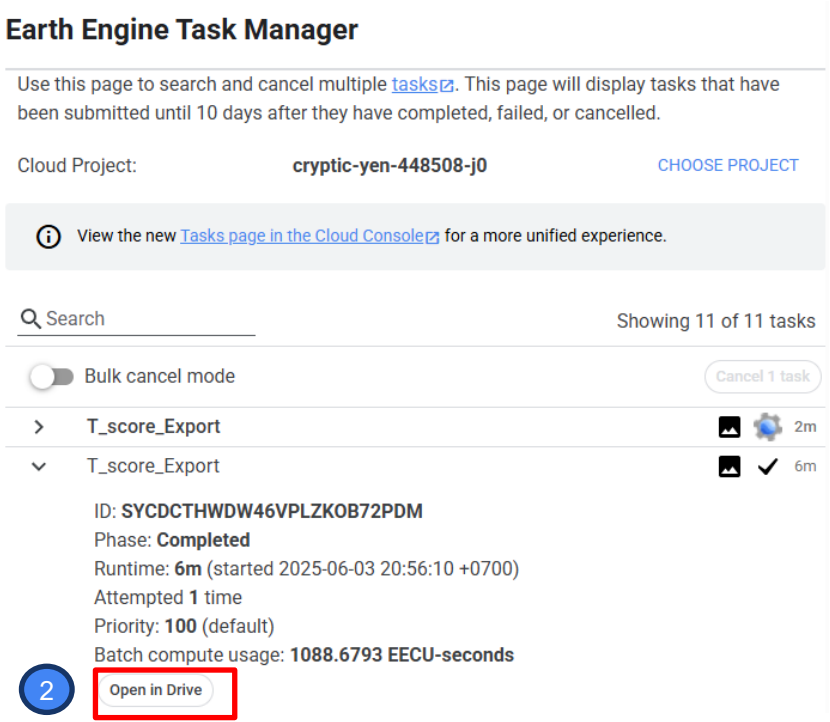
12. Results

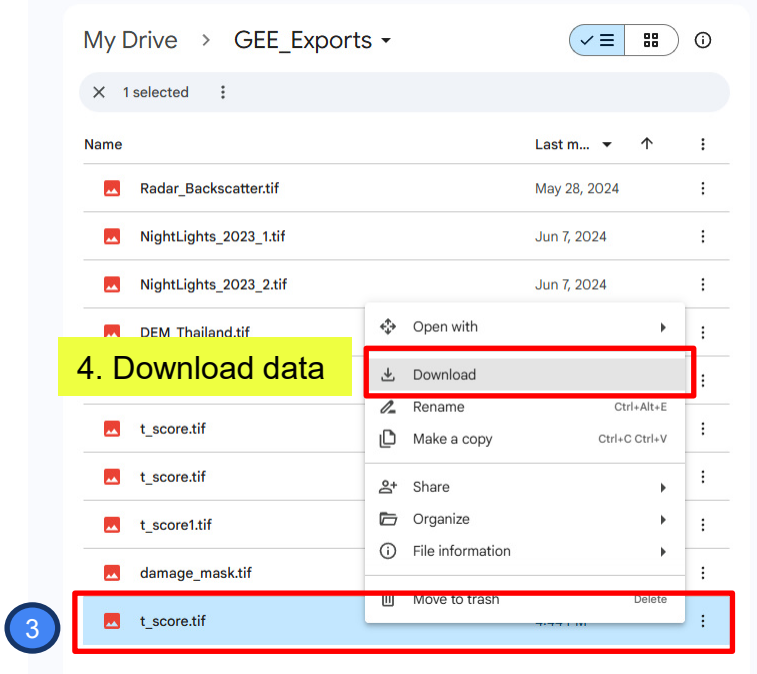

All layers on/off
Esri.WorldImagery
T-test (T_statistic)
T-test (T_statistic)
1 band (Grayscale)
3 bands (RGB)
T_statistic
Stretch:
Custom
Range:
1.1 – 5.0
Opacity:
1.00
Palette
Gamma
Classes:
Any
Colormap:
Palette:
#ffffb2, #fecc5c, #fd8d3c, #f03b20, #bd
2
3
4
5
Import
Apply
ipyleaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community, Google Earth Engine

13. Download data

- Use this link to check the download status of the exported image in Google Drive.

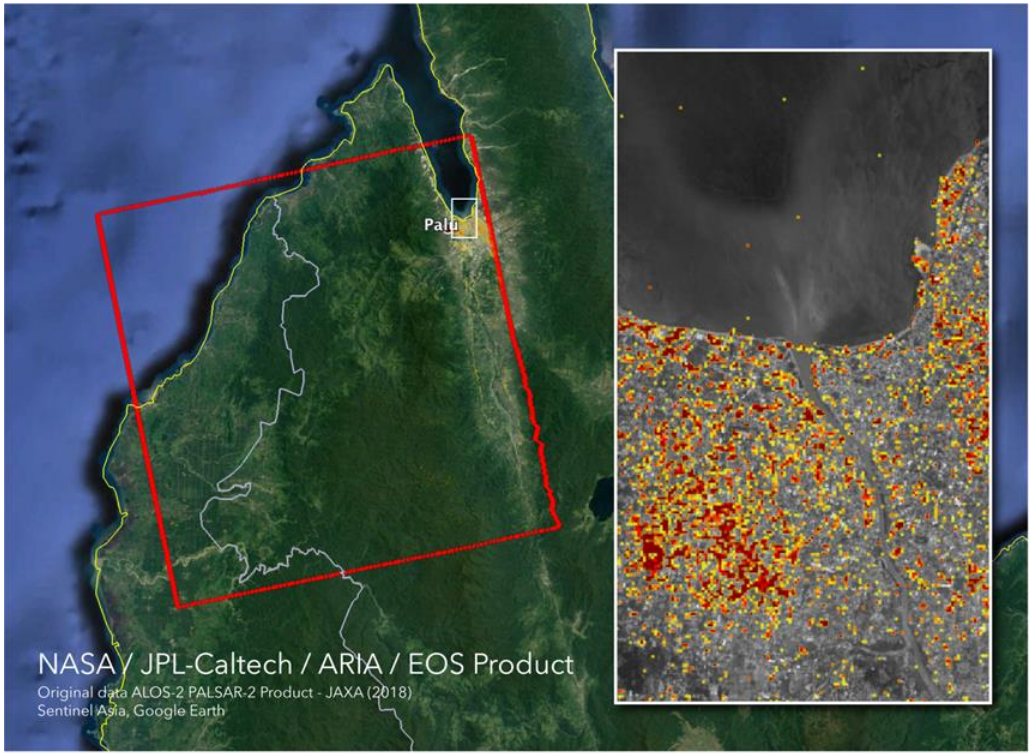
1. Go to >> https://code.earthengine.google.com/tasks <<





Exercise

- Create a T-score image to detect damage caused by the earthquake event.



(https://sentinel-asia.org/EO/2018/article20180928ID.html)

Sentinel Asia activation:

Earthquake in Indonesia

- Occurrence Date (UTC): 28 September, 2018
- SA activation Date(UTC): 28 September, 2018
- Requester: ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre)

AOI:

```
119.799571,-0.869790,
119.946902,-0.946554
```

Reference

Ballinger, O. (2024). Open Access Battle Damage Detection via Pixel-Wise T-Test on Sentinel-1 Imagery. arXiv preprint arXiv:2405.06323.

THANK YOU

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