

# 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

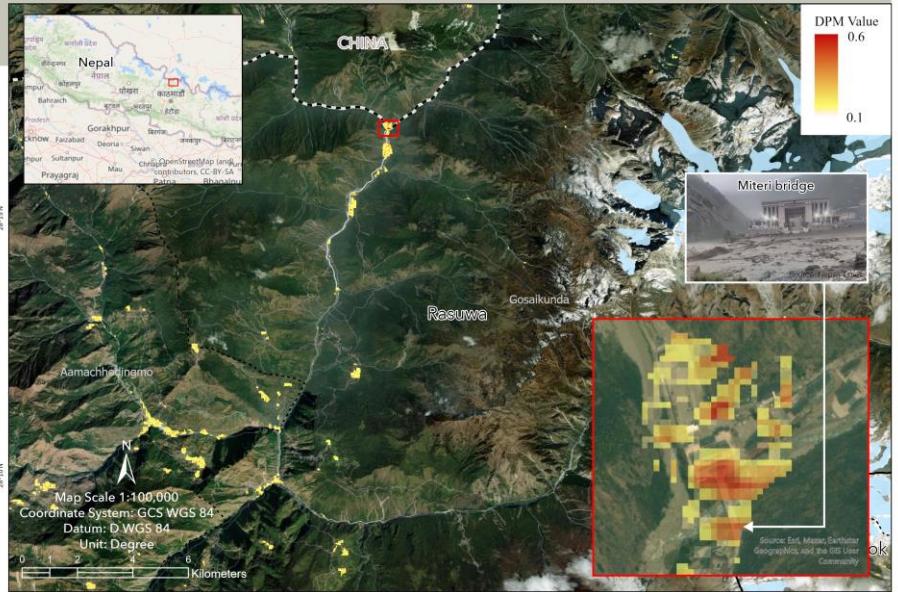
Coordinate	Meaning
85.299951	Minimum Longitude (West)
28.296120	Maximum Latitude (North)
85.398319	Maximum Longitude (East)
28.177378	Minimum Latitude (South)

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

# Overview

## DAMAGE PROXY MAP IN RASUWA DISTRICT, BAGMATI PROVINCE NEPAL

As observed by Sentinel-1 images on 9 July 2025



This map shows the preliminary Damage Proxy Map (DPM) for Rasuwa District, Bagmati Province, Nepal, as of 9 July 2025. According to the latest assessment by the National Disaster Risk Reduction and Management Authority (NDRRA), the disaster was caused by the rupture of a Tibetan glacier lake, resulting in a massive cross-border flood in the region.

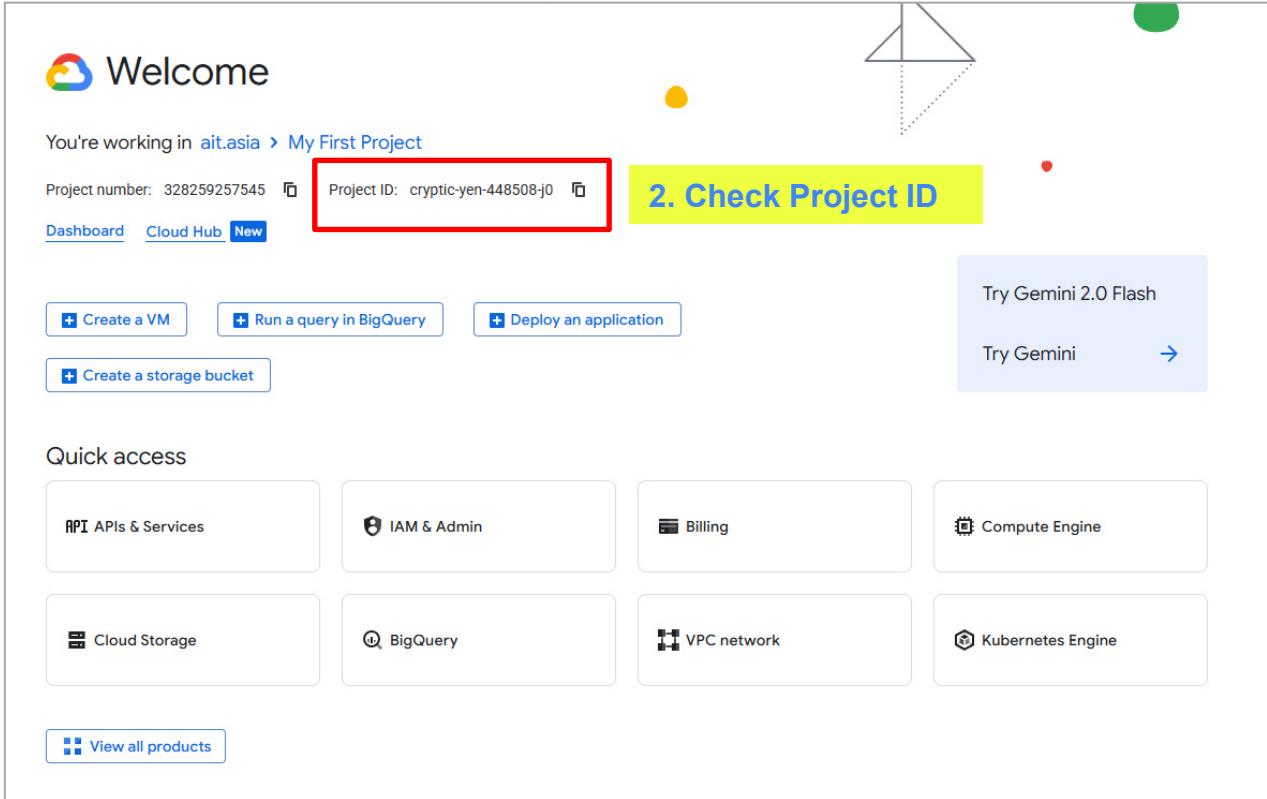
## Sentinel Asia activation:

### 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](https://console.cloud.google.com/) This link: <https://console.cloud.google.com/>



Welcome

You're working in [ait.asia](#) > [My First Project](#)

Project number: 328259257545

Project ID: **cryptic-yen-448508-j0**

[Dashboard](#) [Cloud Hub](#) [New](#)

[Create a VM](#) [Run a query in BigQuery](#) [Deploy an application](#)

[Create a storage bucket](#)

2. Check Project ID

Try Gemini 2.0 Flash

Try Gemini →

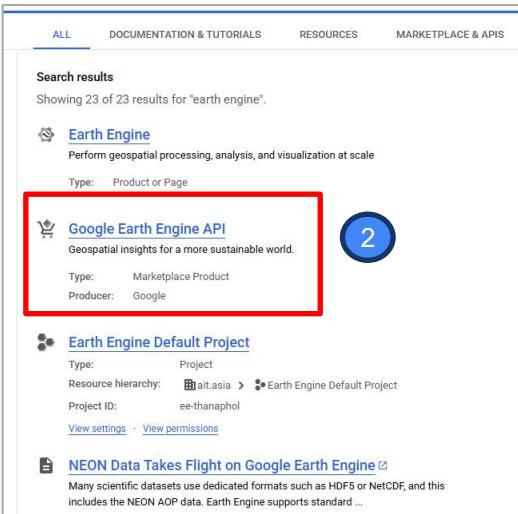
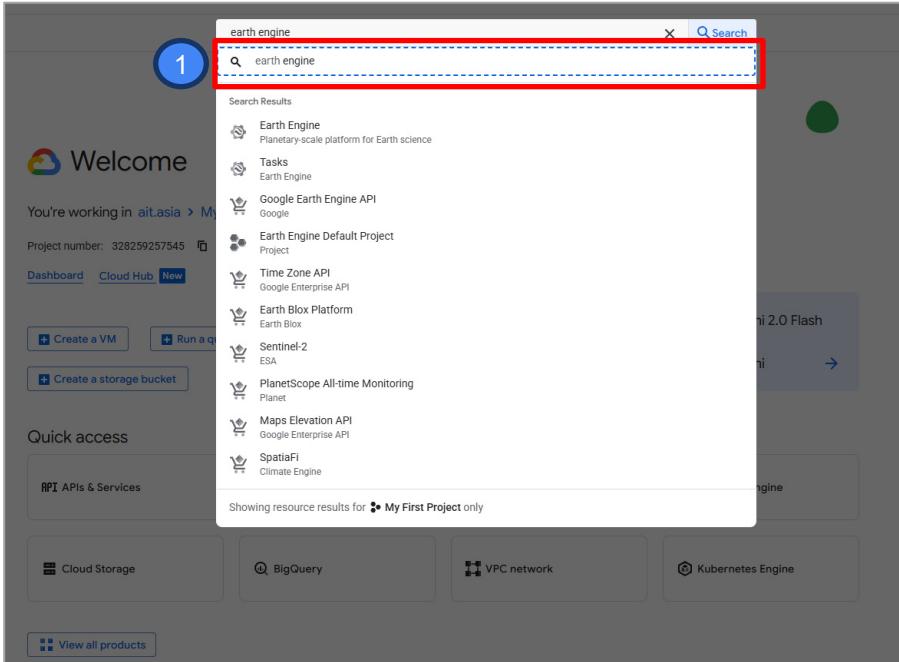
Quick access

- [API APIs & Services](#)
- [IAM & Admin](#)
- [Billing](#)
- [Compute Engine](#)
- [Cloud Storage](#)
- [BigQuery](#)
- [VPC network](#)
- [Kubernetes Engine](#)

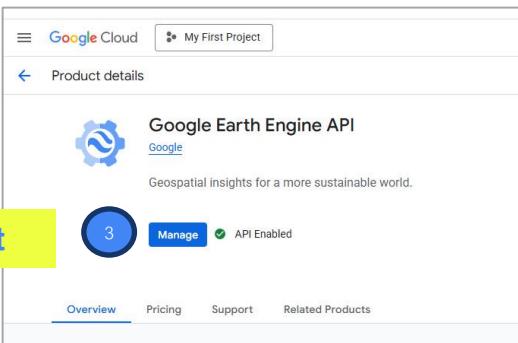
[View all products](#)

## 2. Check Google Earth Engine API

### 1. Search Earth Engine

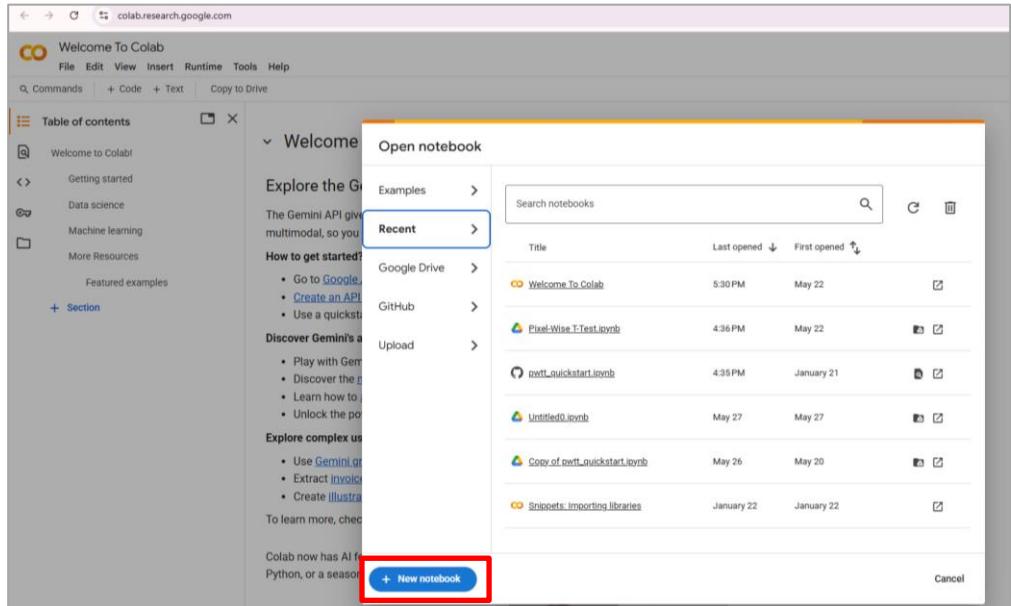


### 3. Check API Enabled or not



# 3. Open Google Colab

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



Welcome To Colab

File Edit View Insert Runtime Tools Help

Commands + Code + Text Copy to Drive

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Welcome to Colab

Getting started

Data science

Machine learning

More Resources

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Section

Explore the Gemini API

The Gemini API gives you access to a wide range of multimodal, so you can quickly and easily build AI-powered applications.

How to get started?

- Go to Google Colab
- Create an API key
- Use a quickstart notebook

Discover Gemini's capabilities

- Play with Gemini
- Discover the power of Gemini
- Learn how to use Gemini
- Unlock the potential of Gemini

Explore complex use cases

- Use Gemini for data analysis
- Extract insights from data
- Create illustrations with Gemini

To learn more, check out the Gemini documentation.

Colab now has AI-powered code completion, so you can quickly and easily build AI-powered applications.

Python, or a season.

+ New notebook

Open notebook

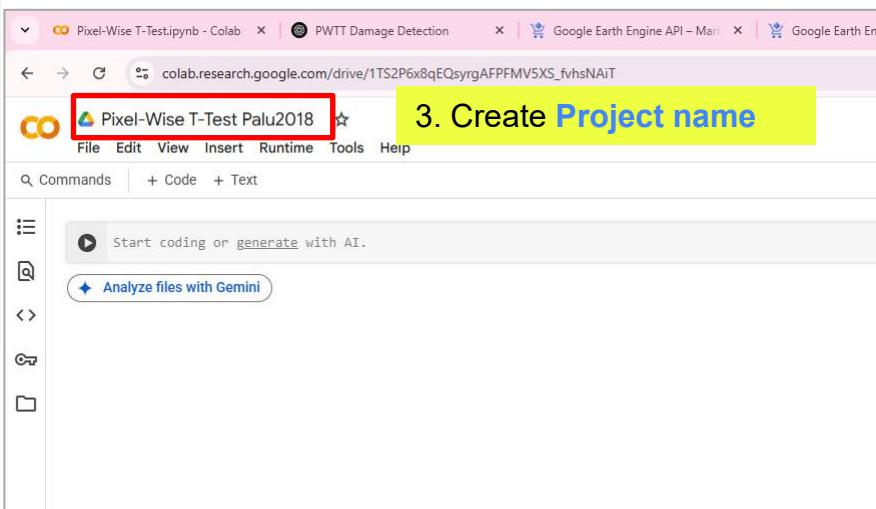
Recent

Search notebooks

Title	Last opened	First opened	⋮
Welcome To Colab	5:30PM	May 22	⋮
Pixel-Wise T-Test.ipynb	4:36PM	May 22	⋮
bert_quickstart.ipynb	4:35PM	January 21	⋮
Untitled0.ipynb	May 27	May 27	⋮
Copy of bert_quickstart.ipynb	May 26	May 20	⋮
Snippets: Importing libraries	January 22	January 22	⋮

Cancel

2. Create New notebook



Pixel-Wise T-Test Palu2018

File Edit View Insert Runtime Tools Help

Commands + Code + Text

Start coding or generate with AI.

Analyze files with Gemini

3. Create Project name

## 4. Install and clone PWTT

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

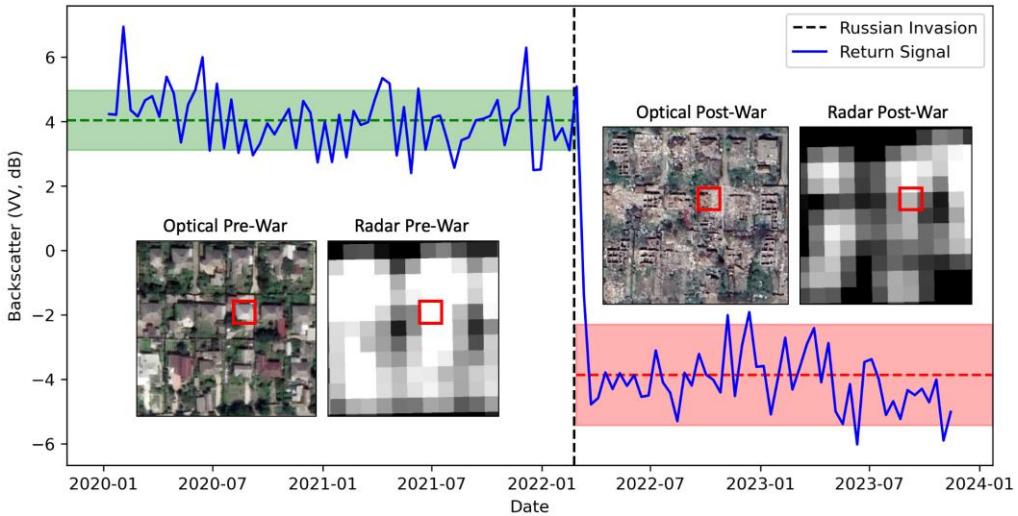
```
!git clone https://github.com/oballinger/PWTT  
%cd PWTT/code
```

- Import required Python libraries

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

# Pixel-Wise T-Test (PWTT)

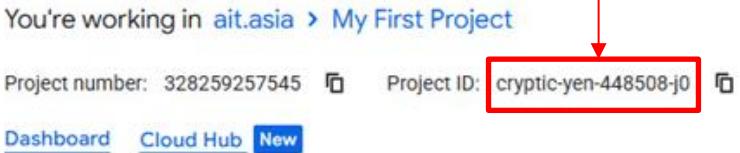
- A new algorithm for battle damage detection using Sentinel-1 SAR imagery
- Fast, lightweight, and generalizable
- PWTT compares mean radar backscatter before and after conflict.
- Applies a pixel-wise T-test to detect significant changes.
- T-score =  $(\text{Mean\_before} - \text{Mean\_after}) / \text{Std\_combined}$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



## 5. Authenticate and initialize GEE using a cloud project

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

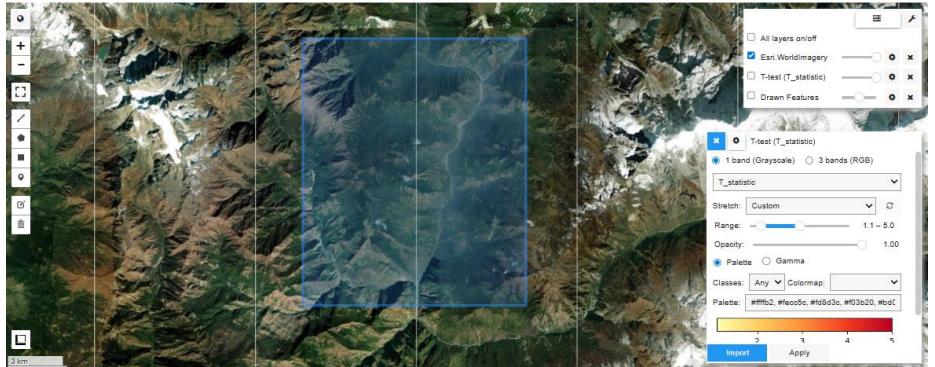
```
project_name = 'YOUR PROJECT NAME'  
ee.Authenticate()  
ee.Initialize(project=project_name)
```

A screenshot of the Google Cloud Welcome screen, identical to the one above. It shows the "Welcome" message, the project name "ait.asia > My First Project", the project number "328259257545", and the project ID "cryptic-yen-448508-j0". The "Project ID" text is highlighted with a red box, and a red arrow points from this box to the "cryptic-yen-448508-j0" text in the code block above.

## 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)
28.296120	Maximum Latitude (North)
85.398319	Maximum Longitude (East)
28.177378	Minimum Latitude (South)

## 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)
```

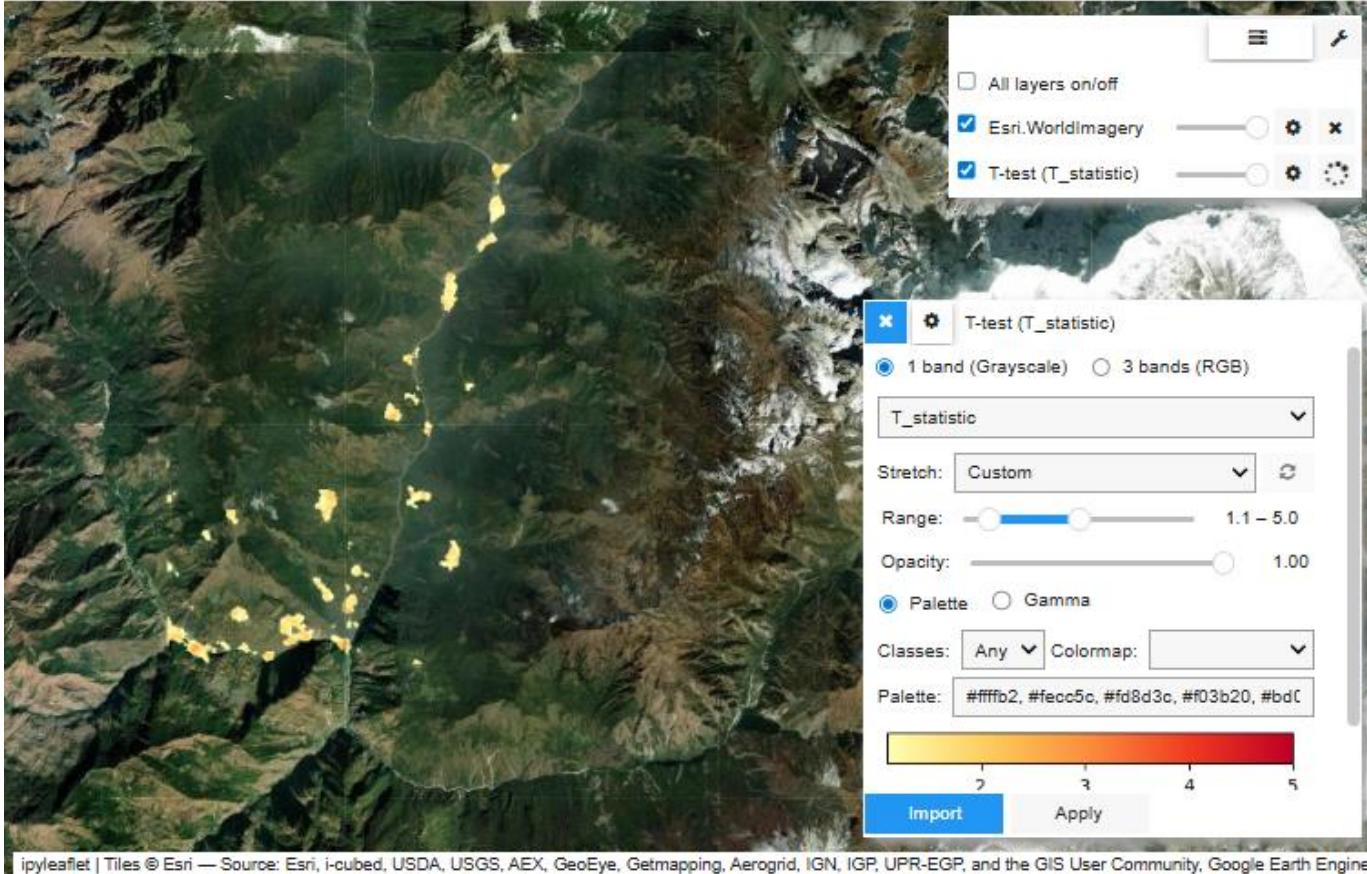
## 11. Export data

- 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



## 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)

### Earth Engine Task Manager

Use this page to search and cancel multiple [tasks](#). This page will display tasks that have been submitted until 10 days after they have completed, failed, or cancelled.

Cloud Project: **cryptic-yen-448508-j0** [CHOOSE PROJECT](#)

 View the new [Tasks page in the Cloud Console](#) for a more unified experience.

 Search

Showing 11 of 11 tasks

 Bulk cancel mode

 Cancel 1 task

 T\_score\_Export

 2m

 T\_score\_Export

 6m

ID: SYCDCTHWDW46VPLZKOB72PDM

Phase: **Completed**

Runtime: **6m** (started 2025-06-03 20:56:10 +0700)

Attempted 1 time

Priority: **100** (default)

Batch compute usage: **1088.6793 EECU-seconds**

 Open in Drive

My Drive > GEE\_Exports

Name

Last m...

 Radar\_Backscatter.tif

May 28, 2024

 NightLights\_2023\_1.tif

Jun 7, 2024

 NightLights\_2023\_2.tif

Jun 7, 2024

 DEM\_Thailand.tif

 Open with

 Download

4. Download data

 Rename

Ctrl+Alt+E

 Make a copy

Ctrl+C Ctrl+V

 Share

 Organize

 File information

 damage\_mask.tif

 Move to trash

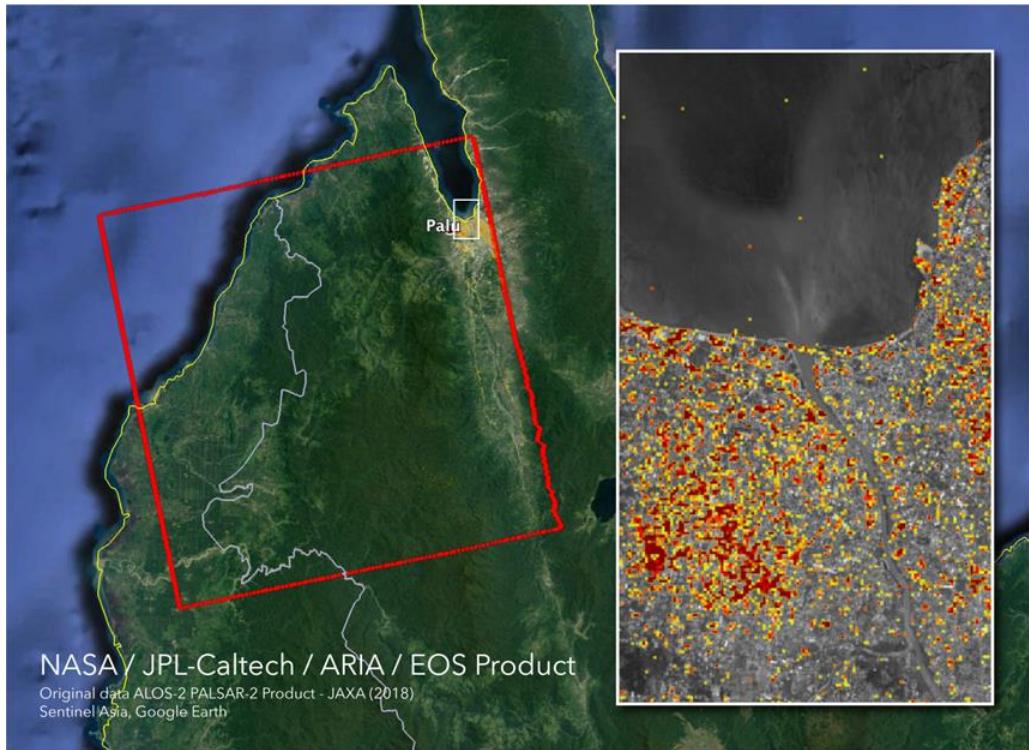
Delete

 t\_score.tif

3

# 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

Geoinformatics Center, Asian Institute of Technology

