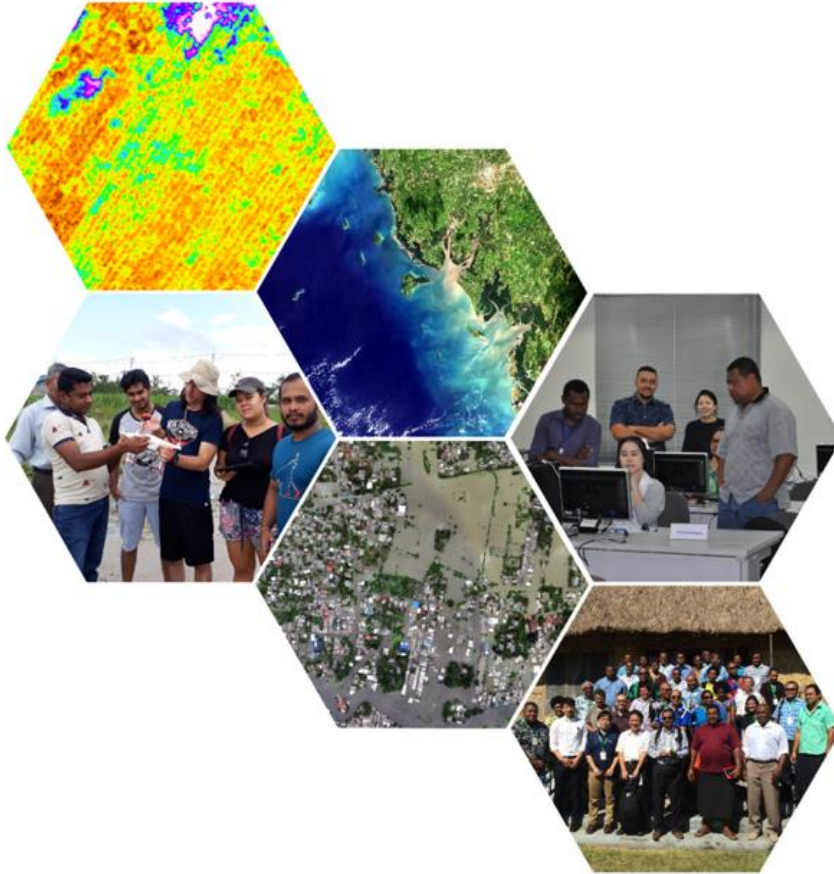


Damage assessment using SAR data (pixel-wise t-test)



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)

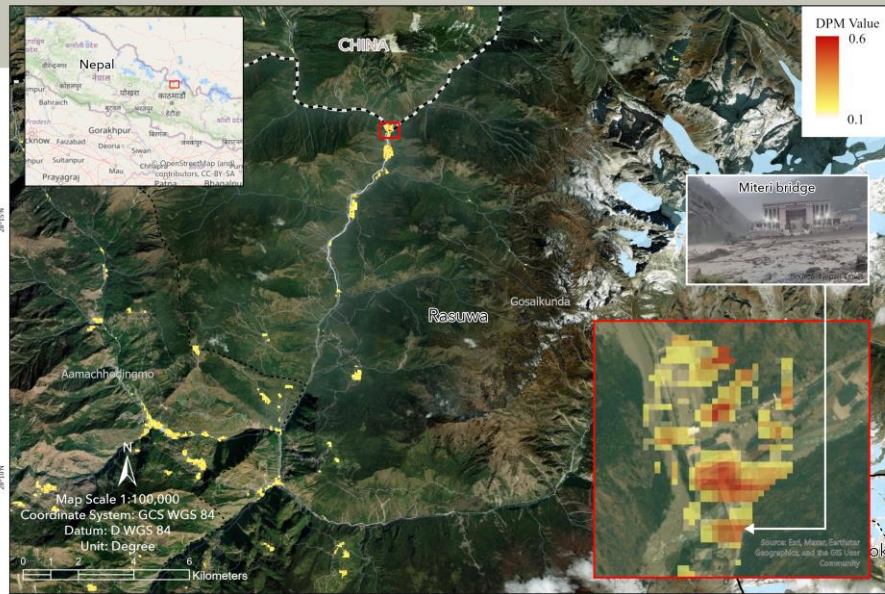
Overview

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 initial assessment by the National Disaster Risk Reduction and Management Authority (NDRRMA), the disaster was caused by the rupture of a Tibetan glacier lake, resulting in a massive cross-border flood in the region.



9
NUMBER OF DEATHS



20
MISSING PERSONS

Source: The Himalayan Times, 10/7/2025

This map serves as a guideline for identifying potentially damaged areas within human settlements. However, accuracy may be limited, especially over vegetated or mountainous terrain, where some damage might not be detected by satellite radar.

- Province Boundary
- District Boundary
- Municipality Boundary
- Waterbody
- Waterway
- Road

Satellite Image:
Pre-disaster : Sentinel-1,
15 and 27 June 2025

Post-disaster : Sentinel-1,
9 July 2025

Contains modified Copernicus
Sentinel data (2025)

GIS Data:
Road © OSM (2025)
Administrative Boundary © GADM (2025)

Map product made by GIC-AIT (v1.0).

Disclaimer: The accuracy of this product
is not validated.

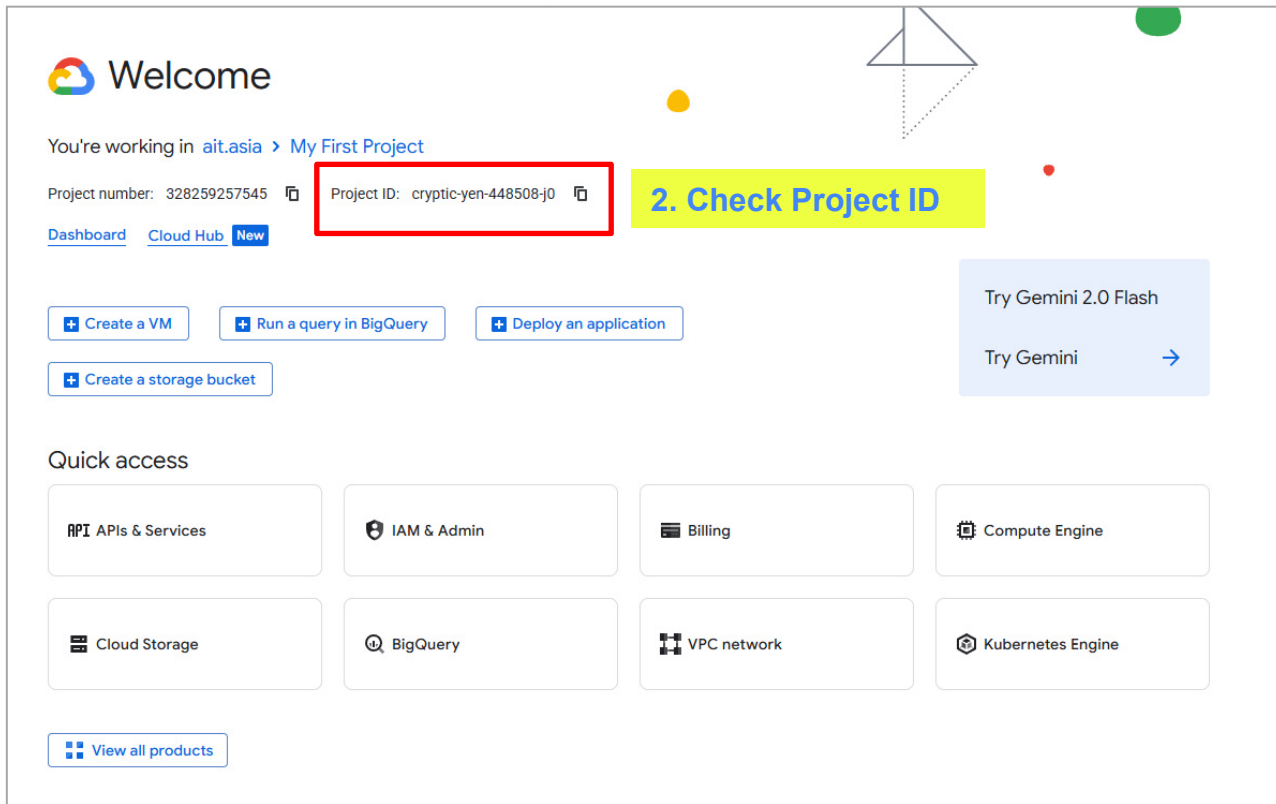
Sentinel Asia activation:

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/>



The screenshot shows the Google Cloud Platform console dashboard. At the top, it says "Welcome" and "You're working in [ait.asia](#) > [My First Project](#)". Below this, the "Project number" is 328259257545 and the "Project ID" is **cryptic-yen-448508-j0**, which is highlighted with a red rectangular box. To the right of the Project ID, there is a yellow box with the text "2. Check Project ID". Below the project information, there are several buttons: "Create a VM", "Run a query in BigQuery", "Deploy an application", and "Create a storage bucket". On the right side, there is a blue box with the text "Try Gemini 2.0 Flash" and "Try Gemini" with a right arrow. At the bottom, there is a "Quick access" section with eight tiles: "APIs & Services", "IAM & Admin", "Billing", "Compute Engine", "Cloud Storage", "BigQuery", "VPC network", and "Kubernetes Engine". At the very bottom, there is a button that says "View all products".

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](#)

Try Gemini 2.0 Flash

Try Gemini →

Quick access

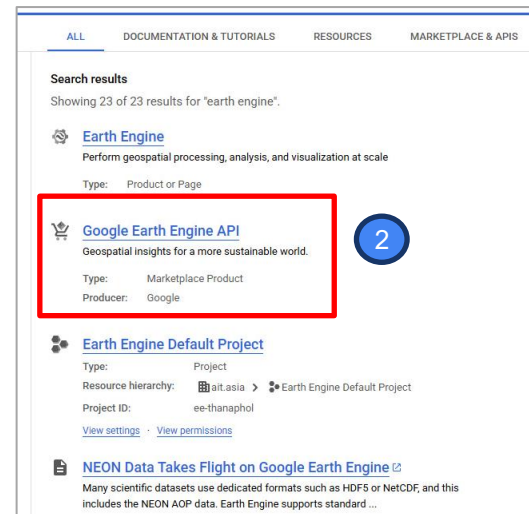
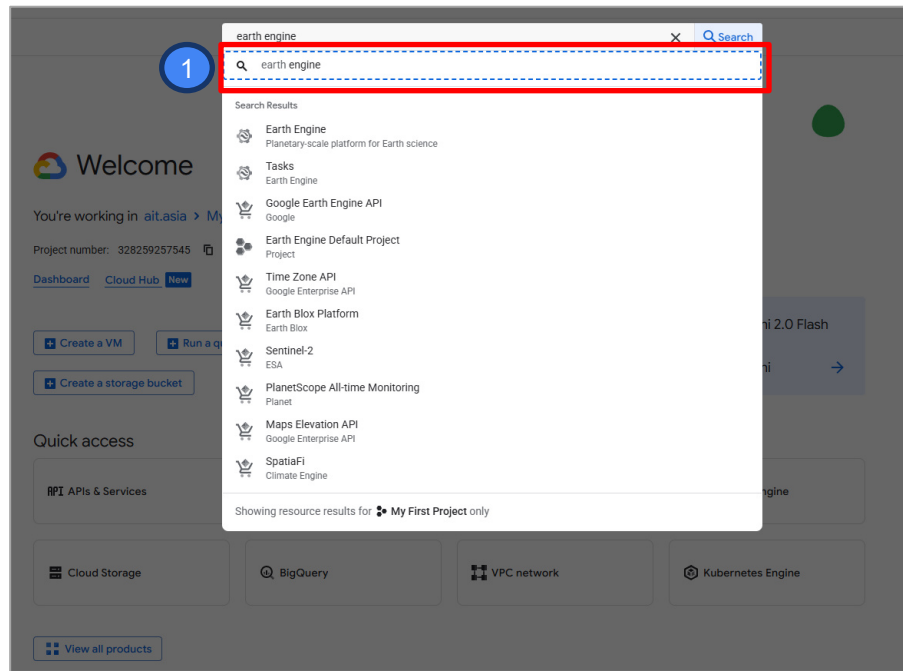
APIs & Services IAM & Admin Billing Compute Engine

Cloud Storage BigQuery VPC network Kubernetes Engine

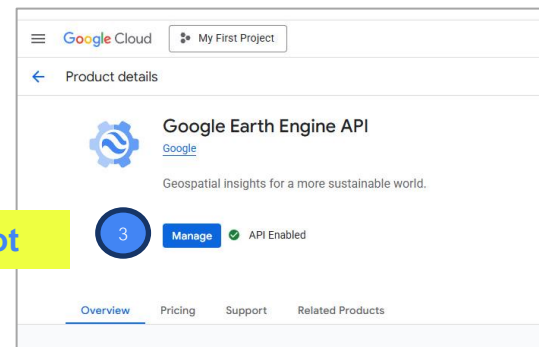
[View all products](#)

2. Check Google Earth Engine API

1. Search Earth Engine



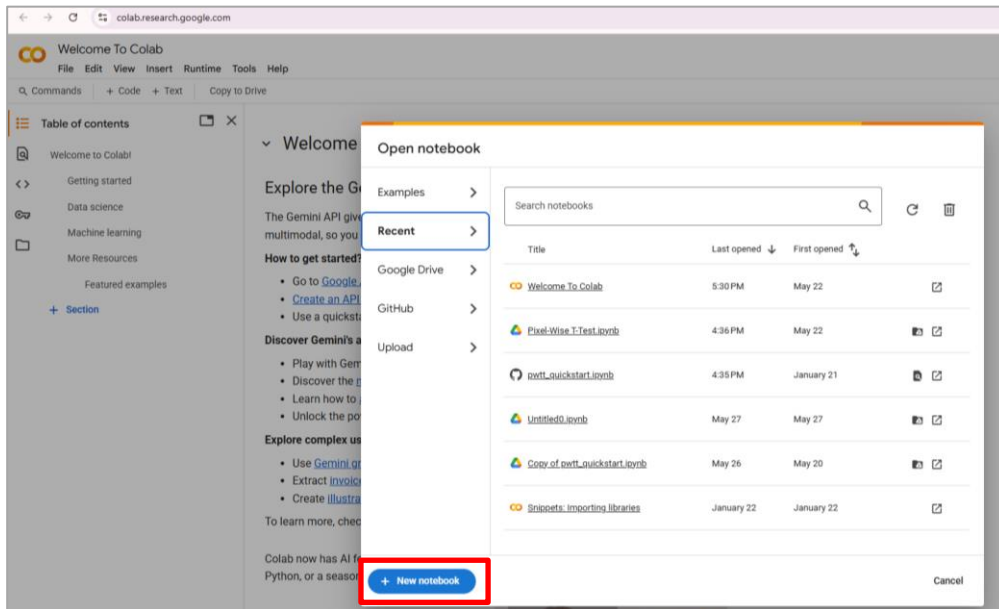
3. Check API Enabled or not



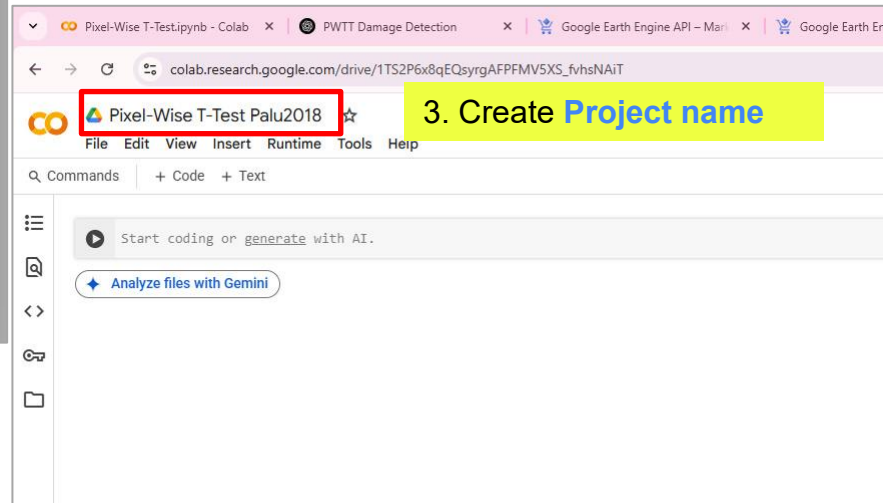
3. Open Google Colab

1. Go to

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



2. Create New notebook



4. Install and clone PWTT

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

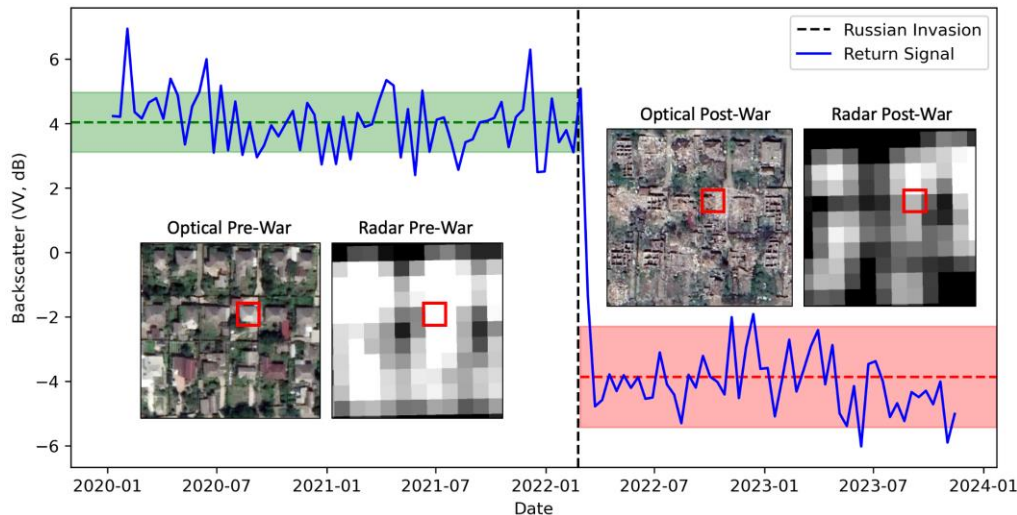
```
!git clone https://github.com/oballinger/PWTT  
%cd PWTT/code
```

- 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.
- $T\text{-score} = (\text{Mean_before} - \text{Mean_after}) / \text{Std_combined}$
- 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)
```



Welcome

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

Project number: 328259257545



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



[Dashboard](#)

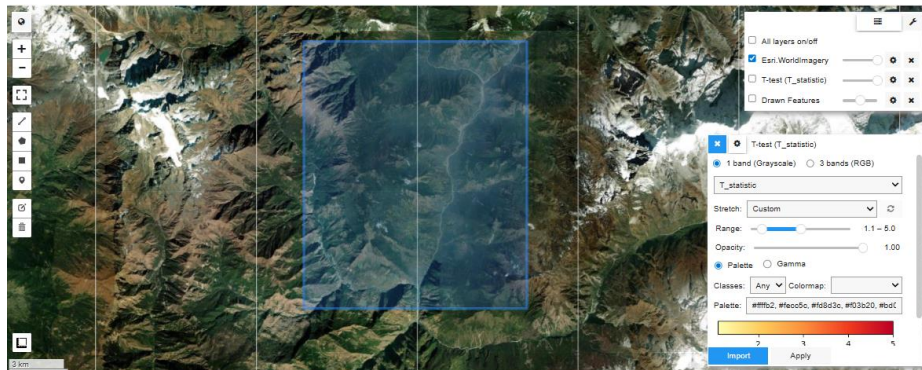
[Cloud Hub](#)

[New](#)

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(  
    aoι=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.

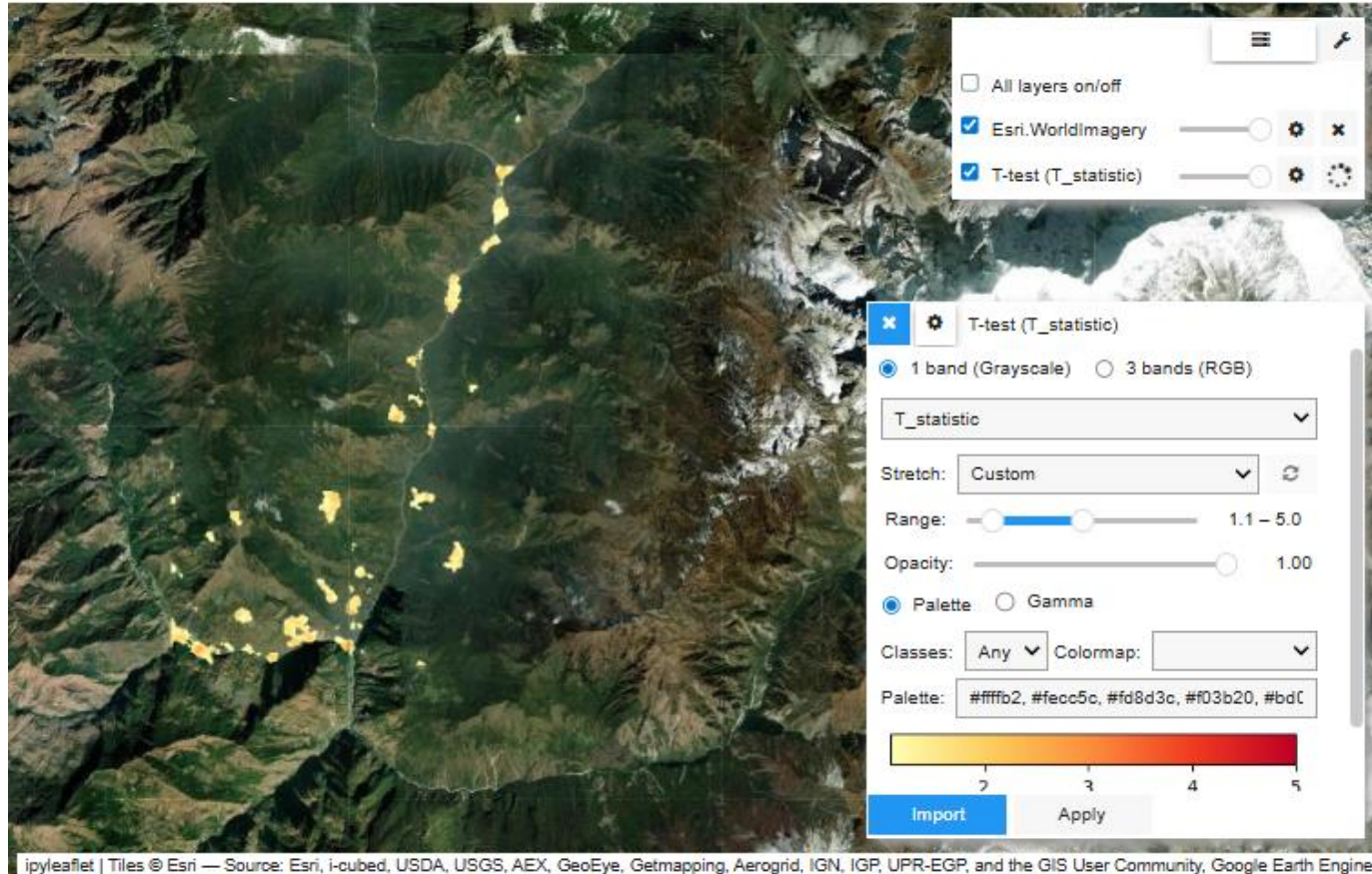
```
Map = geemap.Map(basemap='SATELLITE')  
Map.centerObject(gaza, 12)  
Map.addLayer(t_score, t_score_vis, 'T-test  
(T_statistic)')  
display(Map)
```

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: SYCDCTHWDW46VPLZK0B72PDM

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**

2

[Open in Drive](#)

My Drive > GEE_Exports ▾

1 selected

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		
 t_score.tif		
 t_score.tif		
 t_score1.tif		
 damage_mask.tif		
 t_score.tif		

4. Download data

Download

Rename

Make a copy

Share

Organize

File information

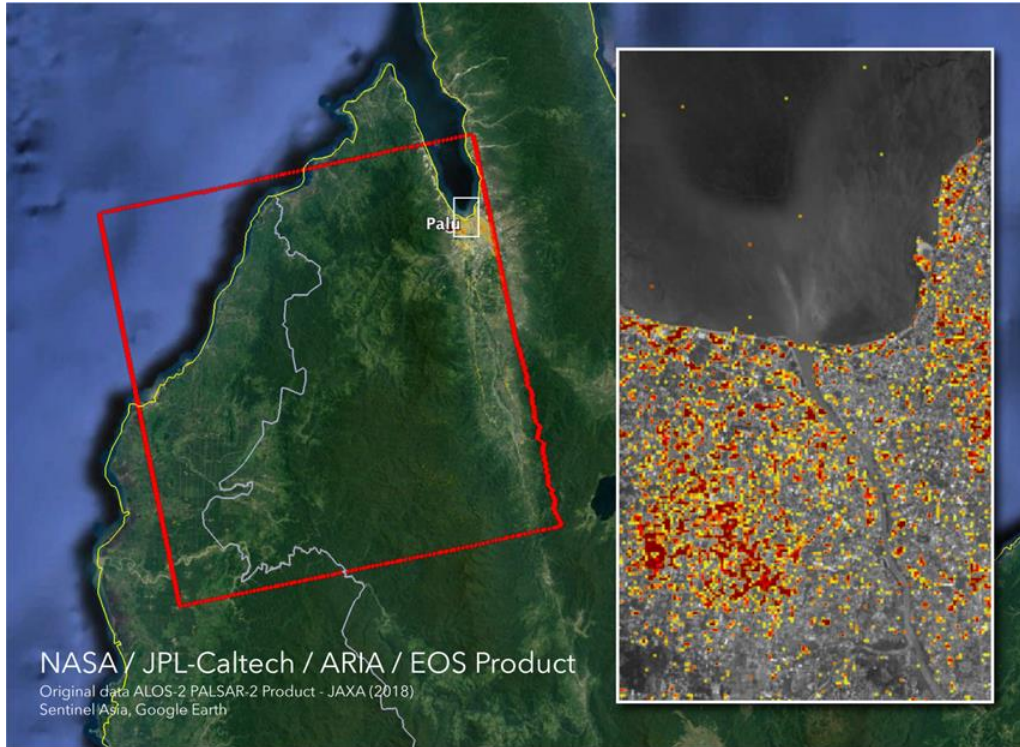
Move to trash

Delete

3

Exercise

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



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](https://arxiv.org/abs/2405.06323).

THANK YOU

Geoinformatics Center, Asian Institute of Technology

