Identifying Global Landslides Using Satellite Imagery and Machine Learning in GEE with SLIDT (Satellite Landslide Identification And Detection Tool)

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Motivation and Objectives

WHY:

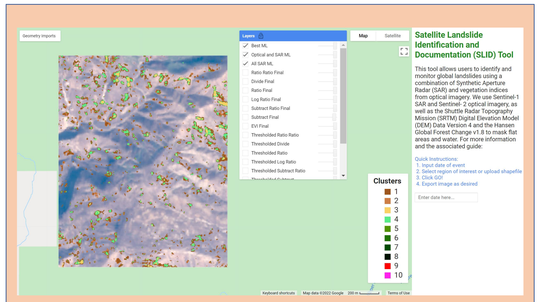
- Climate change → Increased precipitation in some regions → Increased number and impact of landslides
- Optical, Synthetic Aperture Radar (SAR), and Digital Elevation Model (DEM) image processing can be expensive and difficult, thus, there is a need for a free, open-source, easy-to-use tool to monitor mass movements

HOW:

- Use free, pre-processed satellite data to automatically detect landslides through Google Earth Image (GEE)
- Detect drastic changes in vegetation and surface deformation utilizing Sentinel-1 Multispectral Instrument and Sentinel-1 SAR amplitude ground range detected imagery

GOALS:

- Look at four different landslide examples in different climates (arctic, tropical, sub-tropical) and triggers (precipitation, glacial melting, seismic) to analyze global accuracy
- Create a click-and-go tool that can identify global landslides using satellite imagery and machine learning called SLIDT or Satellite Landslide Identification and Detection Tool



Preview of SLIDT: Displaying description, instructions, date and geometry input requirements all in one interface

Methodology

Workflow for Optimizing Landslide Change Detection

Input:

- Insert before and after dates – a range of 1 month (~6 images) is recommended for averaging all images to improve results
- Assign study area as a geometry layer by uploading shapefile or draw polygon in the mapping

Optical calculations:

- Mask clouds from Sentinel-2 10m optical data (bands: red (R), blue (B) and near-infrared (NIR))
- Calculate Enhanced Vegetation Index **(EVI)** and EVI Change

1. EVI=2.5 x (NIR-R)/(NIR+6×R-7.5 ×B+1)
2. EVI Change: After EVI - Before EVI

SAR calculations:

- Average ascending and descending of Sentinel-1 C-band ~20m SAR data (polarizations: VV&VH)
- Calculate SAR change rates to identify which highlights landslides the best

1. Subtract: After VV&VH-Before VV&VH
2. Subtract Ratio: #1 then VV/VH
3. Subtract Log Ratio: #1 then VV-VH
4. Ratio: After VV/VH-Before VV/VH
5. After/Before: After VV&VH/Before VV&VH
6. Ratio of After/Before: #5 then VV/VH

Masking (Thresholding and DEM)

- Calculate curvature using NASA Shuttle Radar Topography Mission 30m Digital Elevation Model
- Remove flat areas and water from all imagery to reduce false positives since landslides are not probable in these areas (Handwerger, 2022)

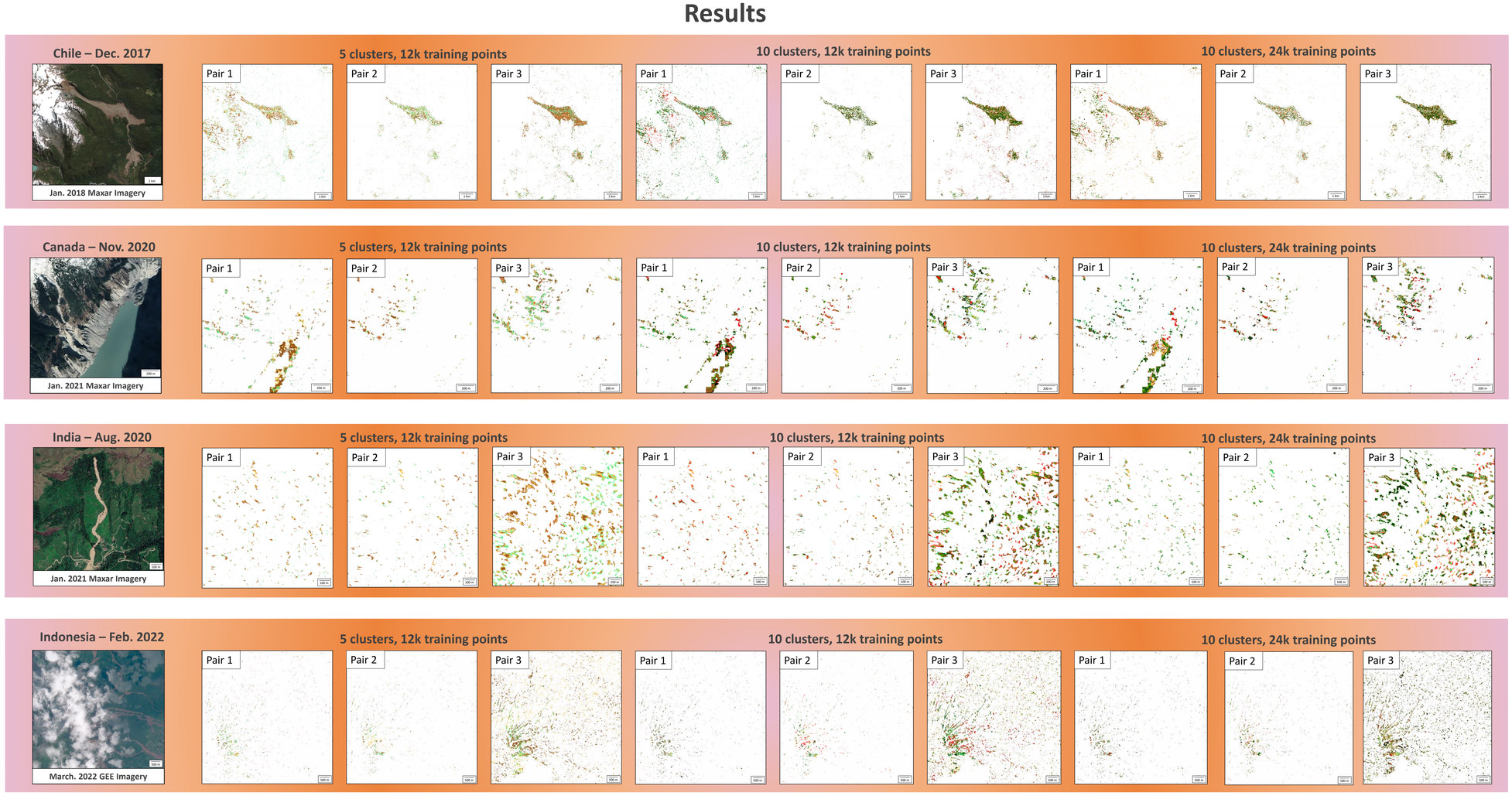
Machine Learning

- Input different combinations of the change rates into clusterer and identify which performs best
  - Clusterer: Weka-k Means
  - Pair 1: All SAR; Pair 2: SAR+ EVI; Pair 3:Best
- Vary the number of training points and clusters for all combinations

Accuracy Assessment

- Create polygons of landslide using Google Earth (~1.5-10m resolution, depending on location)
- Vectorize output from machine learning
- Calculate intersection over union
- Calculate true positives & negatives and false positives & negatives
- Compare scores of all

Results



Observations

- Including all the change ratios does not necessarily mean better identification
- Adding EVI significantly improves speckle noise caused from SAR (Chile), but in other cases (Canada) it takes away information
- Combining EVI, subtract, ratio, divide, ratio ratio delineates landslides best.
- Though Pair 3 shows more connectivity and visually accurate results, there is still many false positives / noise
- Increasing clusters both combines and separates previously distinct classifications
- Different types of noise may be a category and can be further masked
- Landslide origins are labeled differently than landslides body farther away
- Increasing training points changes cluster labels; split several classifications into two

Future Work

- Calculate accuracy scores
- Improve performance and reduce noise
- Finish the click-and-go tool and guide
- Apply automated supervised learning and object-oriented algorithms and compare

References

- Handwerger, A. L., Huang, M.-H., Jones, S. Y., Amatya, P., Kerner, H. R., and Kirschbaum, D. B.: Generating landslide density heatmaps for rapid detection using open-access satellite radar data in Google Earth Engine

Acknowledgments: This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE 2040434.