**Amazonia Disasters**

*Assessing Methods for Gold Mining-related Deforestation Detection in Amazonia Using NASA Earth Observations*

**Project Team**

***Project Team:***

Caley Feemster (Project Lead)

Paxton LaJoie

Marco Vallejos

Perren Wright

***Advisors & Mentors:***

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (The University of Alabama Huntsville)

Kelsey Herndon (NASA SERVIR Science Coordination Office)

Christine Evans (The University of Alabama Huntsville)

Helen Baldwin (NASA SERVIR Science Coordination Office)

Madison Murphy (Optimal GEO)

***Team POC:*** Caley Feemster, cmf0017@uah.edu

***Partner POC:*** Lucio Villa, lvilla@conservacionamazonica.org

**Project Overview**

***Project Synopsis:***

This project assessed the Omnibus Q-test remote sensing algorithm's effectiveness to monitor deforestation caused by artisanal gold mining in the Madre de Dios region of Peru. The DEVELOP team worked with the Asociación para la Conservación de la Cuenca Amazónica (ACCA) to gauge the Omnibus Q-test method's performance applied to imagery from the European Space Agency’s (ESA) Sentinel-1 C-band Synthetic Aperture Radar (C-SAR) by comparing it against PlanetScope imagery and Landsat 8 Operational Land Imager (OLI) surface reflectance imagery. The project will help the team’s partner organization by providing recommendations to improve the accuracy and overall performance of the Omnibus Q-test algorithm, based on an analysis of the results.

***Abstract:***

Artisanal and small-scale gold mining (ASGM) is responsible for a large fraction of deforestation and disturbance in Amazonia. These activities cause severe impacts on the rainforest ecosystem and socioeconomic state of the region. NASA DEVELOP partnered with the Asociación para la Conservación de la Cuenca Amazónica (ACCA), NASA SERVIR Science Coordination Office, and the Spatial Informatics Group to enhance ASGM-related deforestation detection methods. ACCA currently uses the Omnibus Q-test Change Point Detection Algorithm to identify changes in Synthetic Aperture Radar (SAR) monthly-aggregated temporal data from the Sentinel-1 satellite. The team determined the algorithm's accuracy by comparing a stratified random sample of change points against data from January 2019 to June 2020 identified using PlanetScope and Landsat 8 Operational Land Imager (OLI) Earth observations through Collect Earth Online. Our results indicated a users' accuracy of 55% for temporal change detection and producer's and user's accuracies of 99% and 97%, respectively, for detecting when change did not occur. Of the labeled change points, only 19% were due to mining activity. This research can help our partners have a more accurate understanding of where illegal gold mining may be taking place and inform decisions to remediate this activity.

***Key Terms:***

deforestation, gold mining, Amazonia, Omnibus Q-test, Change Point Detection Algorithm, Sentinel-1 C-SAR, Landsat 8 OLI

***National Application Area Addressed:*** Disasters

***Study Location:*** Madre de Dios, Peru

***Study Period:*** January 2019 – June 2020

***Community Concerns:***

* Artisanal and small-scale gold mining (ASGM) caused large disturbances in the Amazonia ecosystem and was responsible for 900 hectares of deforestation in the area of La Pampa, Peru, during 2018 alone.
* Soil degradation is a considerable concern due to toxic heavy metals and lack of nutrients leading to permanent ecosystem damage, thus permanently altering the landscape.
* Gold mining contributes to a decrease in water quality due to the mercury vapors released into the ecosystem after the amalgamation process for gold retrieval.

***Project Objectives:***

* Create sampling points of the study area
* Identify the temporal change points
* Generate user's and producer's accuracy of the Omnibus Q-test algorithm
* Create a StoryMap to provide partners with an educational and outreach tool

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Asociación para la Conservación de la Cuenca Amazónica**  | Lucio Villa, Remote Sensing & GIS Technical Expert  | End User | Yes |
| **NASA SERVIR Science Coordination Office**  | Andrea Nicolau, Amazonia Regional Science Associate | Collaborator | No |
| **Spatial Informatics Group** | John Dilger, Research Scientist | Collaborator | Yes |

***Decision-Making Practices & Policies:***

ACCA currently uses the SAR-based Omnibus Q-test algorithm that utilizes Sentinel-1 C-SAR imagery to identify deforested areas in Amazonia. The algorithm uses data points to filter forest losses by identifying deforestation areas associated with mining activities. ACCA then utilizes this information to indicate potential new or growing unauthorized gold mining locations and alert authorities to protect Amazonia's landscape. However, the algorithm's preliminary results produced low accuracy rates and mistakenly identified landcover change that was not reflected in reference data, making it challenging to promptly and accurately identify the areas where mining was taking place.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** |  Surface reflectance | The spectral bands for surface reflectance were used to generate the Normalized Difference Fraction Index (NDFI) to identify forest degradation during reference data generation for the accuracy assessment. |
| **Sentinel-1 C-SAR** | Backscatter | Radiometric terrain corrected VH (vertical transmit and horizontal receive) and VV (vertical transmit and vertical receive) backscatter was used for the Omnibus Q-test algorithm. |
| **PlanetScope**  | Surface reflectance | Planet surface reflectance was used as reference data to create an accuracy assessment. |

***Software & Scripting:***

* Google Earth Engine API – Sampling, Omnibus Q-test
* Python 3.8 – Data consolidation and organization
* R 4.03 – Confusion matrices, producer’s and user’s accuracies
* ESRI ArcGIS ArcMap 10.5 – Creation of study area and results maps
* ESRI ArcGIS Online StoryMap – Educational representation and outreach
* Collect Earth Online – Data collection for accuracy assessment of maps

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Change Assessment Methodology Performance Metrics** | Landsat 8 OLISentinel-1 C-SARPlanetScope | This will provide our partners with information about the accuracy of the Omnibus Q-test change detection algorithm for identifying areas with mining-related deforestation. | I |
| **Amazonia Disasters StoryMap** | Landsat 8 OLISentinel-1 C-SAR  | An ArcGIS StoryMap will give background, visuals, and an overview of the project that the partner can use as an educational tool for public outreach. | N/A |

***Product Benefit to End User:***

This project provides the partners with an accuracy assessment for the Omnibus Q-test change detection algorithm's performance for identifying mining-related deforestation areas in Amazonia when using monthly aggregated data. The team generated an accuracy assessment by comparing the results of the Omnibus Q-test algorithm against PlanetScope reference data. Partners will utilize this research's outcomes to assist in the generation of an early alert system to detect gold mining activity throughout the region. The results of this project provide a path to monitor multiple other areas within Amazonia as well.

**References**

Bullock, E. L., Woodcock, C. E., & Olofsson, P. (2020). Monitoring tropical forest degradation using spectral unmixing and Landsat time series analysis. *Remote Sensing of Environment*, *238*, 110968. <https://doi.org/10.1016/j.rse.2018.11.011>

Caballero Espejo, J., Messinger, M., Román-Dañobeytia, F., Ascorra, C., Fernandez, L. E., & Silman, M. (2018). Deforestation and forest degradation due to gold mining in the Peruvian Amazon: A 34-year perspective. *Remote Sensing*, *10*(12), 1903. <https://doi.org/10.3390/rs10121903>

Nielsen, A. A., Conradsen, K., Skriver, H., & Canty, M. J. (2017). Visualization of and software for omnibus test-based change detected in a time series of polarimetric SAR data. *Canadian Journal of Remote Sensing*, *43*(6), 582–592. <https://doi.org/10.1080/07038992.2017.1394182>