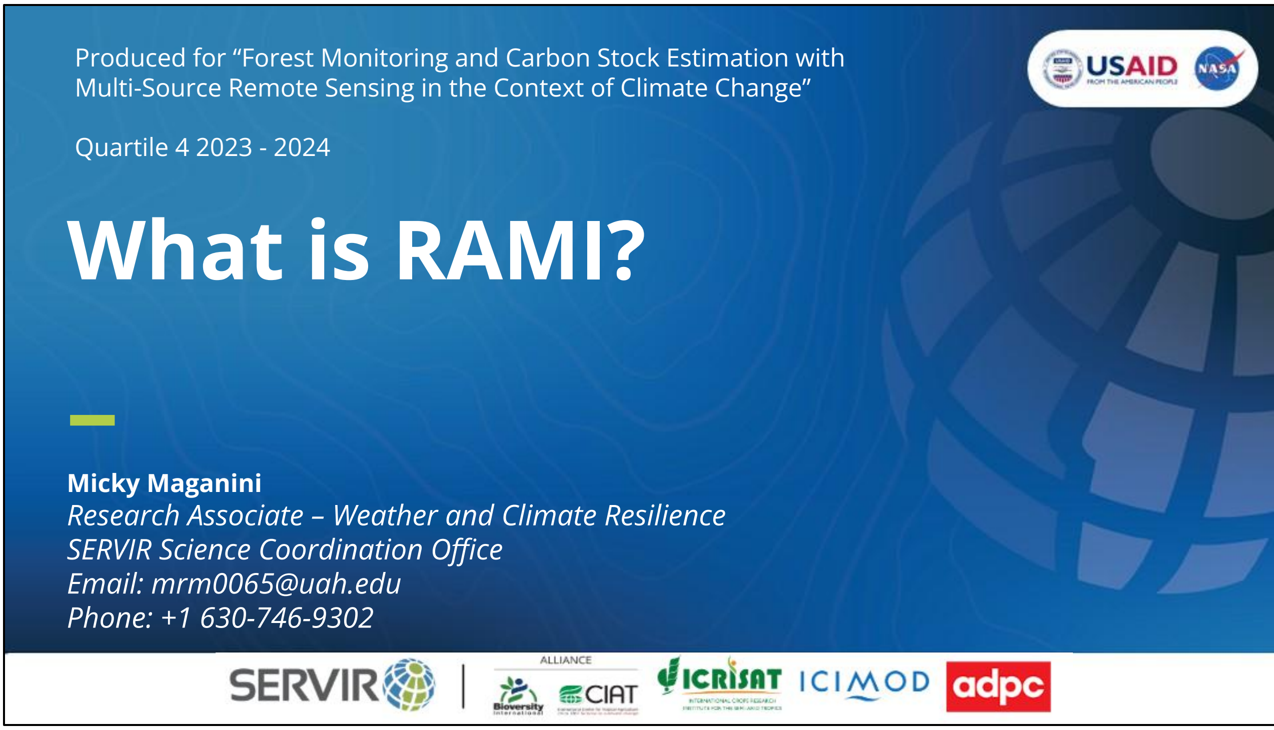


Introduction → RAMI → what RAMI does

Hello everyone ,

My name is Micky Maganini, and I work for SERVIR, a U.S. Government organization and partner of ITC. Today I am going to introduce you to a web-based tool called RAMI that was developed by SERVIR. RAMI is a change detection algorithm used by SERVIR to monitor deforestation in the Amazon due to illegal gold mining.

Context

Before we learn more about RAMI, I want to provide some context about What SERVIR is.

joint program → hubs

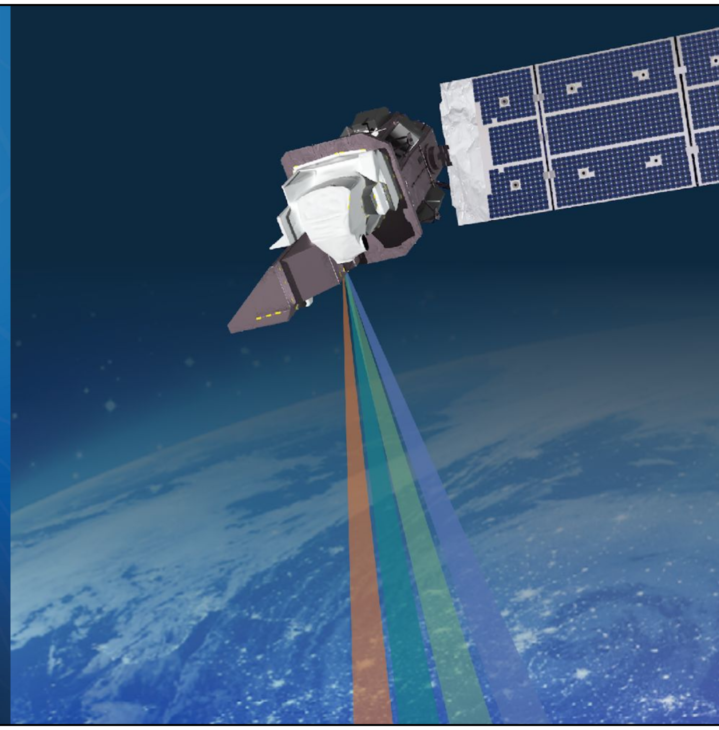
SERVIR is a joint program between NASA and the US Agency for International Development. We develop solutions to address environmental challenges using earth observation data. We work with organizations around the world in five regional hubs to create these solutions.

SERVIR network → ITC & SERVIR

Beyond our regional hub institutions, we partner with organizations in the private sector, intergovernmental organizations, NGOs, and research institutions like ITC. ITC and SERVIR have partnered with each other since 2018 as both institutions apply earth observations to sustainable development on a global scale.

SERVIR

What is RAMI?

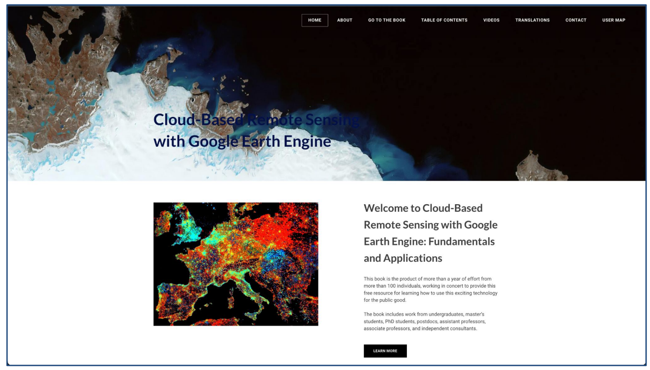


RAMI Background

SERVIR

RAMI (Radar Mining and Monitoring Tool) is…

- Open source
- Documented
- Cloud-based
- Customizable



ACCA
BOSQUES en tus manos
PERÚ Ministerio del Ambiente
SERVIR

RAMI – which stands for the Radar Mining Monitoring Tool, is a change detection algorithm implemented in Google Earth Engine. RAMI consists of a web portal where our end users can see areas that the tool is predicting have undergone change due to deforestation, as well as the code that it runs on. RAMI was co-developed by Conservacion Amazonica, Bosques en tus manos, and SERVIR-Amazonia, and delivers deforestation alerts to Peru's Ministry of the environment. The code is open source and is documented, allowing anyone to use the code for a separate ecological problem and/or geographic region

The Problem

SERVIR

- Illegal Mining in the Peruvian Amazon has cascading impacts on both humans and the environment (Riehl 2020)
- Operation Mercury

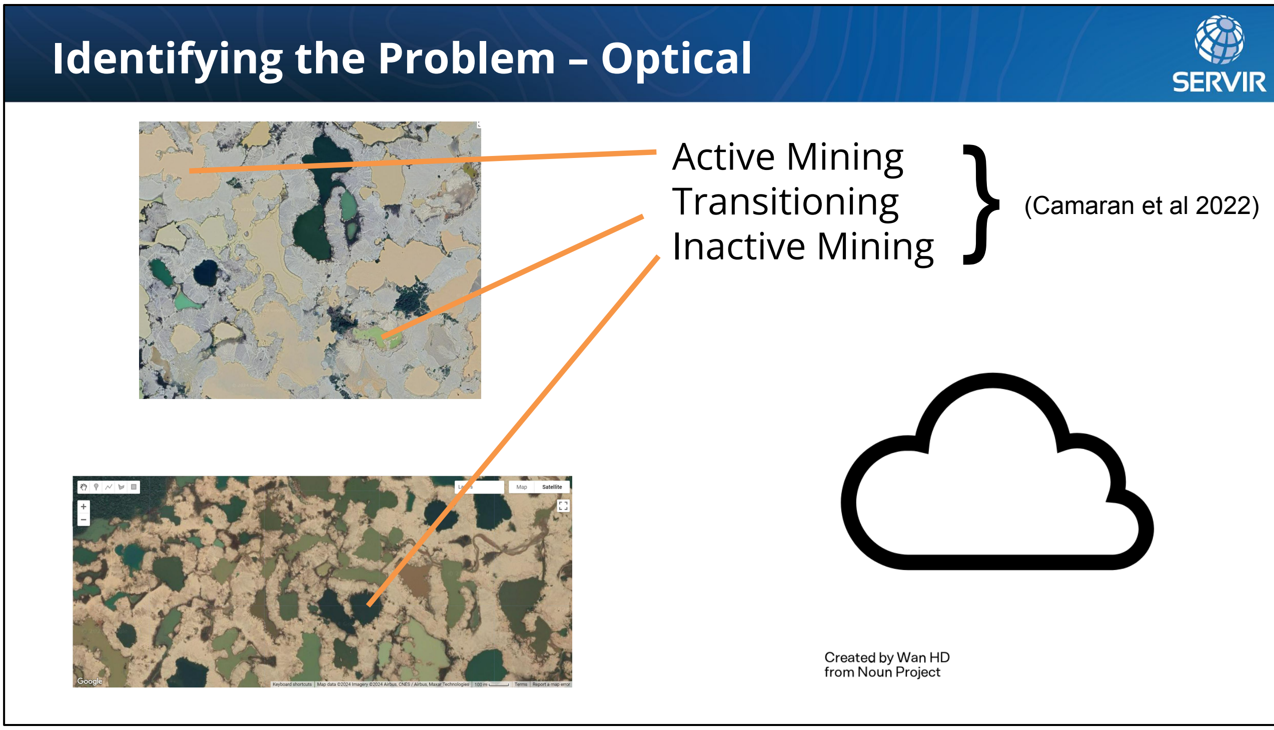
Image Credit: Tomas Munita, AmazonAid

Illegal gold mining is an extremely devastating issue in the Peruvian Amazon. Not only is mining dangerous and destructive, but it attracts other forms of illicit activity. According to the US Secretary of State for International Narcotics and Law Enforcement AFfairs, Richard Glenn stated that since 2010, over 50,000 children have been forced to work in the illegal gold mines in the mining camps in the

Madre de Dios and Puno regions of Peru (U.S. Congress 2019). The mines themselves contain many hazards, exposing workers to wall and mine collapses, landslides, explosive accidents, and mercury exposure. But harmful events do not stop at the mining towns. The use of mercury to extract gold from the soil then enters the rivers and bioaccumulates up the food chain via fish. A study by Basu et al 2018 studied 46 indigenous populations in the Amazon and found mercury levels 7.5 times higher than the background levels in the general population (Basu et al 2018). These harmful impacts of mining are felt disproportionately by indigenous communities in the Amazon, the World Resources Institute found that 6% of total indigenous land in the Amazon

(14.3 mil ha) directly overlaps with mining concessions or illegal mining activities. These populations are affected due to the use of mercury to extract gold from the soil, which then enters the rivers and bioaccumulates up the food chain via fish.

The problem is so severe in the Peruvian Amazon that the Peruvian government launched Operation Mercury in 2019, which aims to eradicate illegal gold mining in the La Pampa Corridor (Riehl 2020). The deforestation alerts generated by RAMI support Operation Mercury.

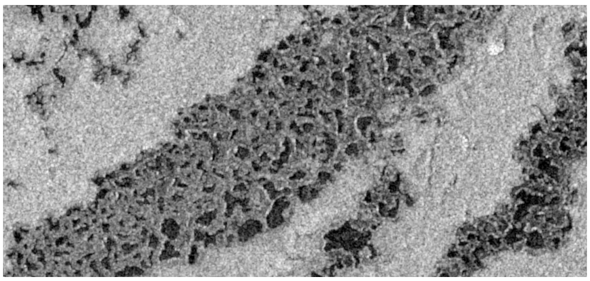


The process of alluvial gold mining involves the removal of forest cover and topsoil, excavation, and the use of water to extract the gold from the loose sediment. Mining ponds are easily identifiable in optical imagery by their distinctive spatial and spectral patterns. The use of water to extract gold from the topsoil results in these mining ponds, the different colors of which indicate the stage at which mining is.

Chalky clay ponds indicate active mining, dark green lakes indicate inactive ponds, and light green ponds are recently active The problem with trying to monitor mining in this region using optical imagery is the persistent presence of clouds.

Identifying the problem – SAR

SERVIR



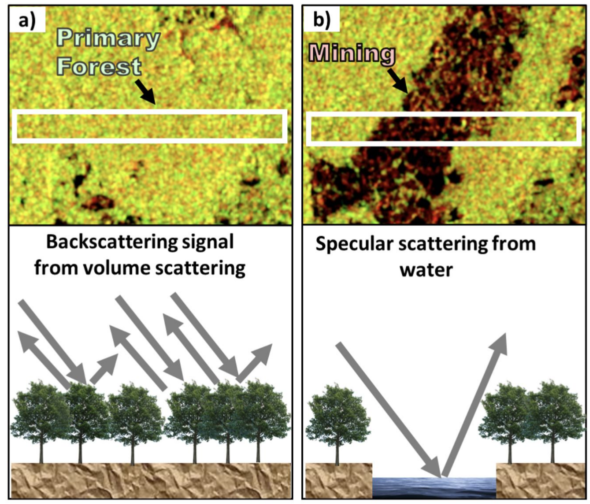


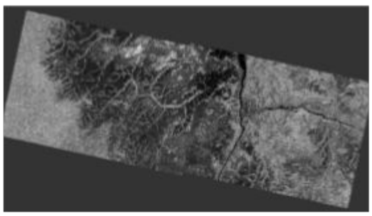
Image Credit: Franz Meyer, SAR handbook

Synthetic Aperture Radar (or SAR) allows us to “see through” clouds, which allows SERVIR-Amazonia to monitor gold mining in the rainy season when cloud cover is persistent. On the left you can see what mining ponds look like in SAR imagery. SAR backscatter is based on the roughness and moisture content of the signal. For surfaces with an equal moisture content, rougher structures will appear brighter than smoother surfaces. Thus, as we can see on the left, we can identify forest as white, the mining ponds as black, and the soil in between the mining ponds as dark gray.

RAMI takes advantage of this backscatter difference between canopy and water, using a change detection algorithm to identify regions that initially have a high backscatter, then transition to a lower backscatter. So while the backscattering signal from forested areas are strong due to volume scattering, the backscattering signal from areas where gold mining is occurring is weak due to specular scattering of the water. This is shown by the schematic on the right side, where the VV band of the SAR data is assigned to the red and blue channel, and the VH band is assigned to the green channel. Areas that appear yellow here are showing a strong backscatter, whereas those darker areas are showing a weak backscatter.

RAMI Workflow

Step 1: Create a Time Series of SAR Images → Step 2: Apply Omnibus Q-test Algorithm → Step 3: Post-processing



$$\ln Q = n\left(pk\ln k + \sum_{i=1}^{k} \ln|X_i| - k\ln\left|\sum_{i=1}^{k} X_i\right|\right),$$

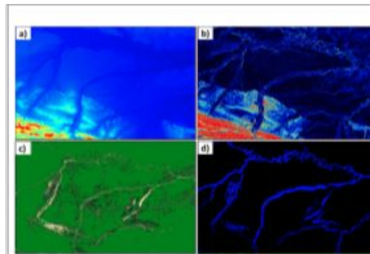


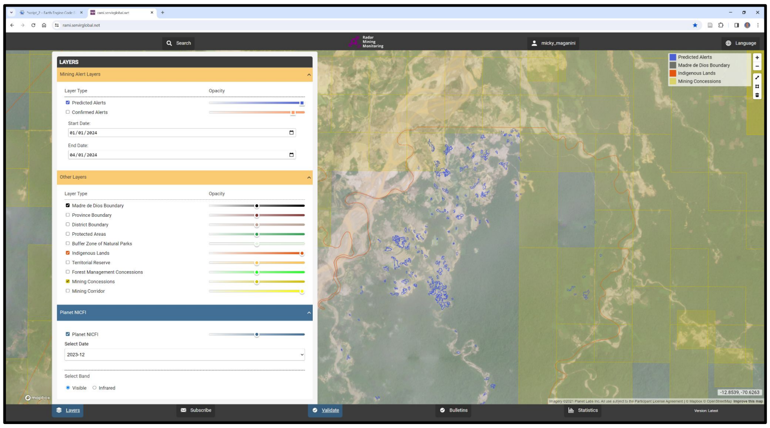
Fig. A1.8.9 Layers used to filter false positives alerts: a) SRTM elevation, red color shows areas over 1000 meters above sea level; b) SRTM slope, red color shows areas with slope over 15 degrees; c) Hansen Global Forest Change, green color shows forested areas updated to 2020; d) JRC Yearly Water Classification History, blue color shows the maximum extent of water surface detected from 1984 to 2020.

Here we can see the general workflow of RAMI. Our first step is to pre-process the SAR data (specifically masking SAR images acquired at an incidence angle less than 31 or greater than 45 degrees), then creating a time series of mosaic of SAR images for a given time, region, and orbit pass. In Step 2, we apply the omnibus Q-test algorithm to our time series to generate change alerts. In Step 3 we will filter and eliminate potential false positive alerts coming from other activities with the same temporal pattern as the mining activity (e.g. natural forest loss by river expansion or water over bare soil during the rainy season). We do this by filtering out alerts that occur at an elevation above 1000 meters, in areas with a slope greater than 15 degrees, areas where there is not forest, and areas that were identified as water bodies. The elevation postprocessing step is taken due to the fact that in the Madre De Dios region, mining occurs in lowland areas. The slope step is taken because radiometric terrain correction is not applied to our SAR data, so steep regions show distortions. The forest step is employed using the Hansen Global Forest Change dataset, and the water step is taken via the JRC Global Surface Water Dataset. The water step is to remove false alerts that occur due to natural forest loss due to changes in river morphology.

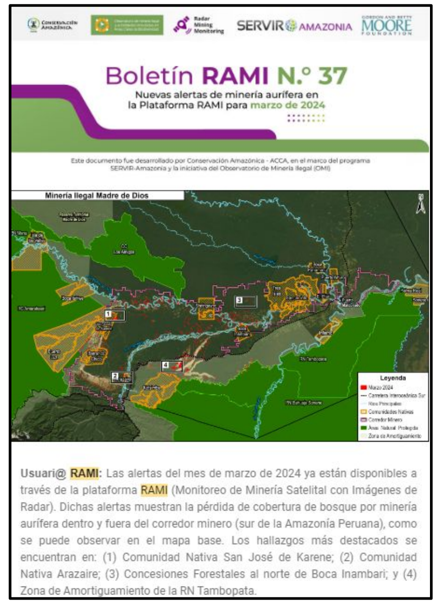
Limitations

Because RAMI is an unsupervised change detection algorithm, the physical cause of detected changes must be inferred from prior knowledge. Second, RAMI is not radiometric terrain corrected because it uses Google Earth Engine. Flores-Anderson et al 2023 found that using RTC products is essential to minimize geolocation errors. Finally, since we use SAR and not optical imagery, we are not able to distinguish between the different stage of the mining life cycle. We can only determine when the forest has been cleared and replaced with water.

RAMI Use Cases



rami.servirglobal.net



Boletín RAMI N.° 37

Nuevas alertas de minería aurífera en la Plataforma RAMI para marzo de 2024

Este documento fue desarrollado por Conservación Amazónica - ACCA, en el marco del programa SERVIR-Amazonia y la iniciativa del Observatorio de Minería Ilegal (OMI)

Usuari@ RAMI: Las alertas del mes de marzo de 2024 ya están disponibles a través de la plataforma RAMI (Monitoreo de Minería Satelital con Imágenes de Radar). Dichas alertas muestran la pérdida de cobertura de bosque por minería aurífera dentro y fuera del corredor minero (sur de la Amazonía Peruana), como se puede observar en el mapa base. Los hallazgos más destacados se encuentran en: (1) Comunidad Nativa San José de Karene; (2) Comunidad Nativa Arazaire; (3) Concesiones Forestales al norte de Boca Inambari; y (4) Zona de Amortiguamiento de la RN Tambopata.

RAMI is not just a product of good research, it's used operationally by SERVIR Amazonia's end users to combat illegal deforestation in real time. RAMI delivers alerts to Peruvian Organizations such as the National Forest Conservation Program for Climate Change Mitigation of Environmental Ministry in Peru, the Representative Organization of Indigenous Peoples in Madre de Dios and FEMA. Monthly reports of mining hotspots are distributed to enforcement agencies, an example of which can be seen on the right. These reports are used by enforcement agencies to dispatch teams to disband illicit mining. There is a open source platform where all of RAMI's alerts are uploaded, so the end users can see how these alerts overlap with different administrative boundaries. As you can see in the graphic, deforestation alerts (shown in blue) often occur outside mining concessions highlighted in yellow, and inside indigenous lands, highlighted in orange.

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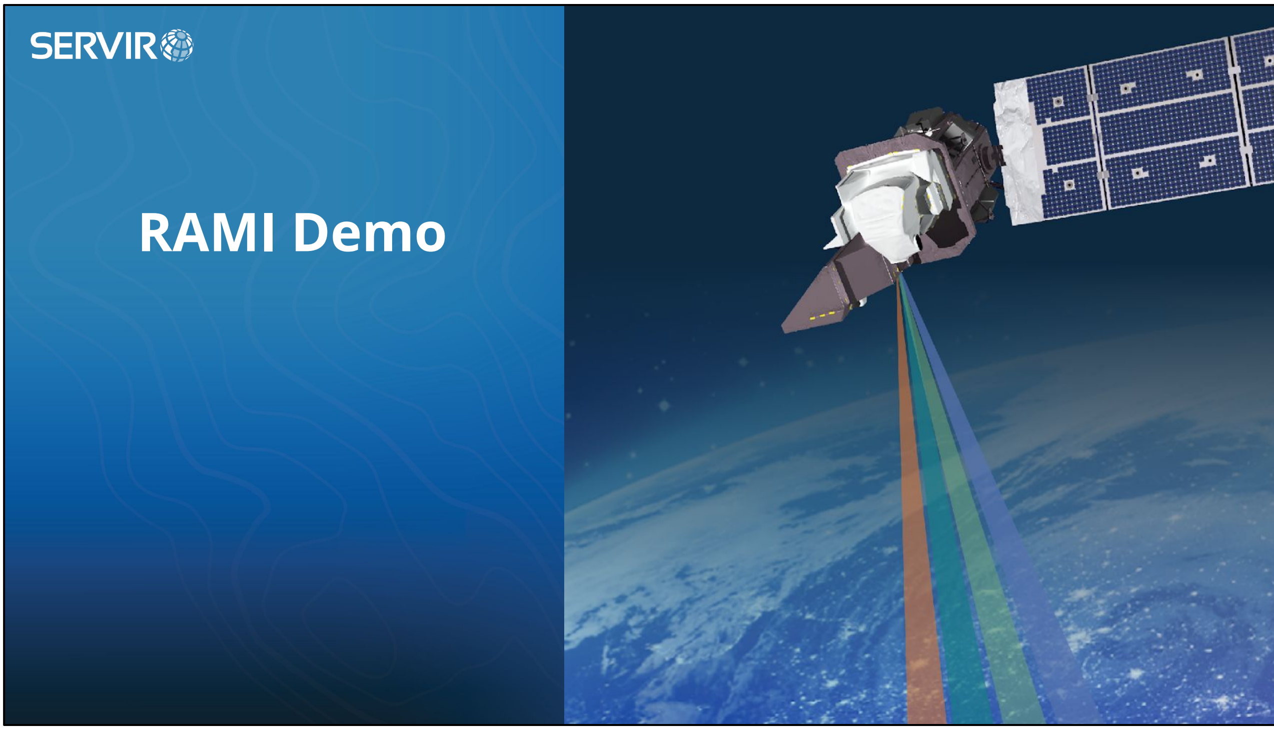

RAMI Demo

So now let’s look at how RAMI works in action


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