



Presented at the FIG Working Week 2023,  
28 May - 1 June 2023 in Orlando, Florida, USA

# FIG WORKING WEEK 2023

28 May - 1 June 2023 Orlando Florida USA

Protecting  
Our World,  
Conquering  
New Frontiers

## An Early Warning Earth Observation System to Detect and Map Forest Disturbances

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## Introduction

- Forests are critical to preserving biodiversity, supporting a stable climate, and providing sustainable livelihoods.
- Country commitments to mitigate and adapt to climate change are an integral part of the 2030 Agenda for Sustainable Development with its 17 global goals that countries have adopted to guide development efforts.
- Other global initiatives such as the Reducing Emissions from Deforestation and Forest Degradation (REDD+) launched by the United Nations Framework Convention on Climate Change (UNFCCC) provide financial incentives for forest-rich developing countries to reduce forest cover loss and degradation.

## Introduction

- The REDD+ mechanism contributes directly to achieving Sustainable Development Goals (SDGs) 13 and 15 - addressing climate change by reducing deforestation and sustainable use of ecosystems.
- REDD+ can also contribute to achieving other SDGs – including those which address poverty reduction, health and well-being, hunger alleviation, and improving institutions.



## Introduction

- Despite efforts by REDD+ participating countries to safeguard the forest, illegal operators, especially in the tropics, are cutting down trees for timber and fossil fuel and turning forest reserves into farmland and mining zones.
- According to the World Economic Forum (2021), unregulated gold mining has caused \$9 billion of economic damage a year in Africa.
- Immediate actions with accurate and up-to-date information on forest disturbances are vital to overcoming these challenges.

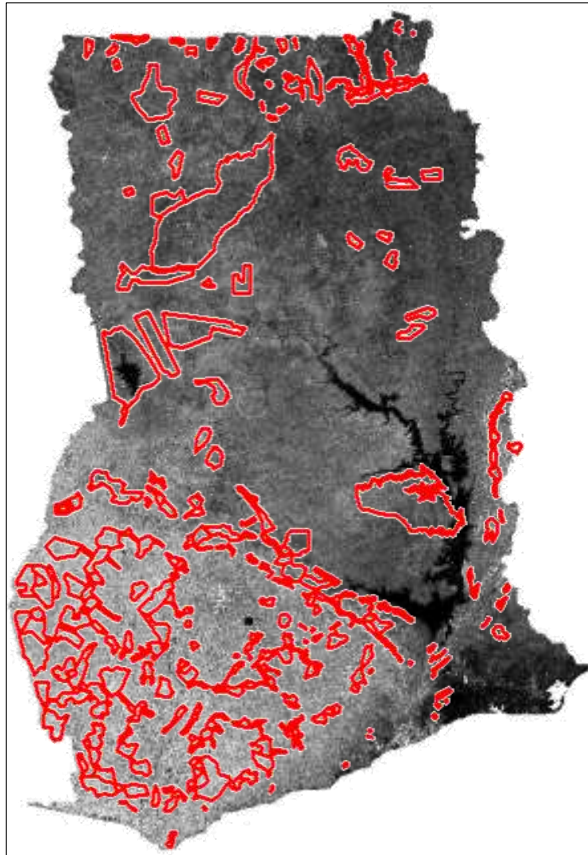
## Introduction

- Traditional means of detecting forest disturbances, such as field surveys and patrols, are time-consuming, expensive, risky, and frequently ineffective.
- Increased availability of open-source earth observation data, such as optical and synthetic aperture radar (SAR) satellite imagery and affordable UAV technologies, have fostered the development of early warning systems for monitoring forest disturbances and mapping the extent of the damage.

## Objective

- To develop a remote sensing service capable of monitoring and mapping the evolution of mining activities and abnormal land cover changes associated with deforestation and degradation.

## Study Area



**266 forest reserves** covering a total of 2.5 million hectares.

## Data

- The service makes use of both Synthetic Aperture Radar (SAR) and optical data.

Earth Observation Data	Data Type	Spatial Resolution	Ownership Cost	Affected by Cloud	Purpose
Sentinel-1	SAR	20 m	Open Source	No	Monitoring
COSMO-SkyMed	SAR	3 m	Commercial	No	Mapping
Sentinel-2	Optical	10 m	Open Source	Yes	Monitoring
Landsat 5	Optical	30 m	Open Source	Yes	Monitoring
Landsat 8	Optical	30 m	Open Source	Yes	Monitoring
Drone	Optical	3 cm - 1 m	Commercial*	No	Mapping



## Data

- SAR unlike optical sensors penetrate the cloud coverage.



**Optical Image**  
(Covered by Cloud)

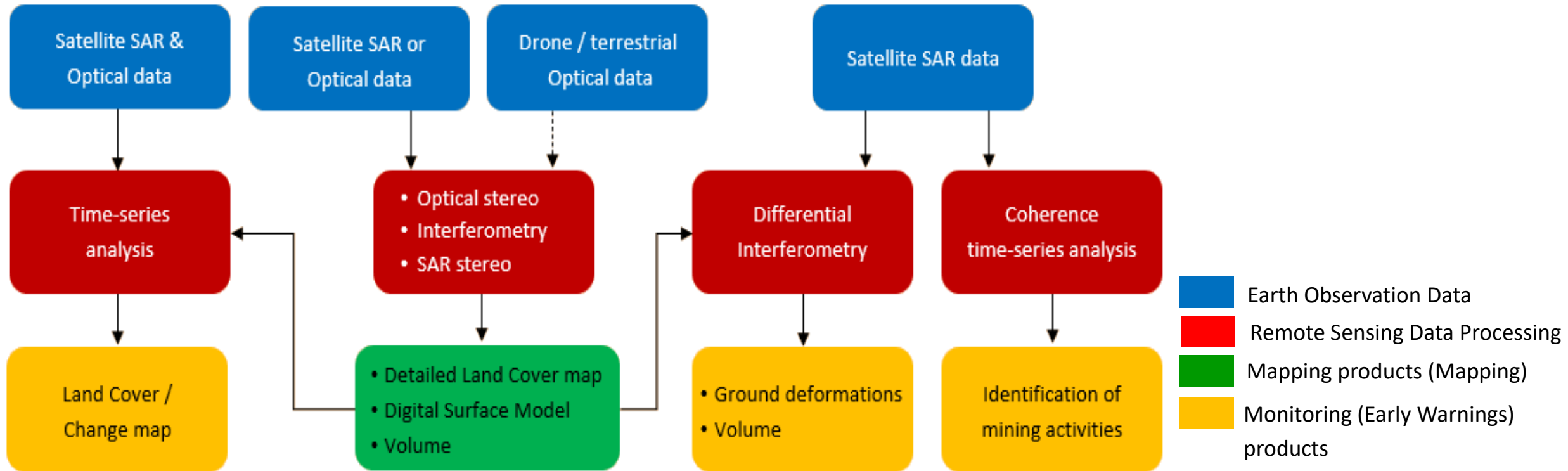


**Optical Image**  
(No Cloud)



**SAR Image**  
(No Cloud)

## Generic Workflow of the Remote Sensing Service

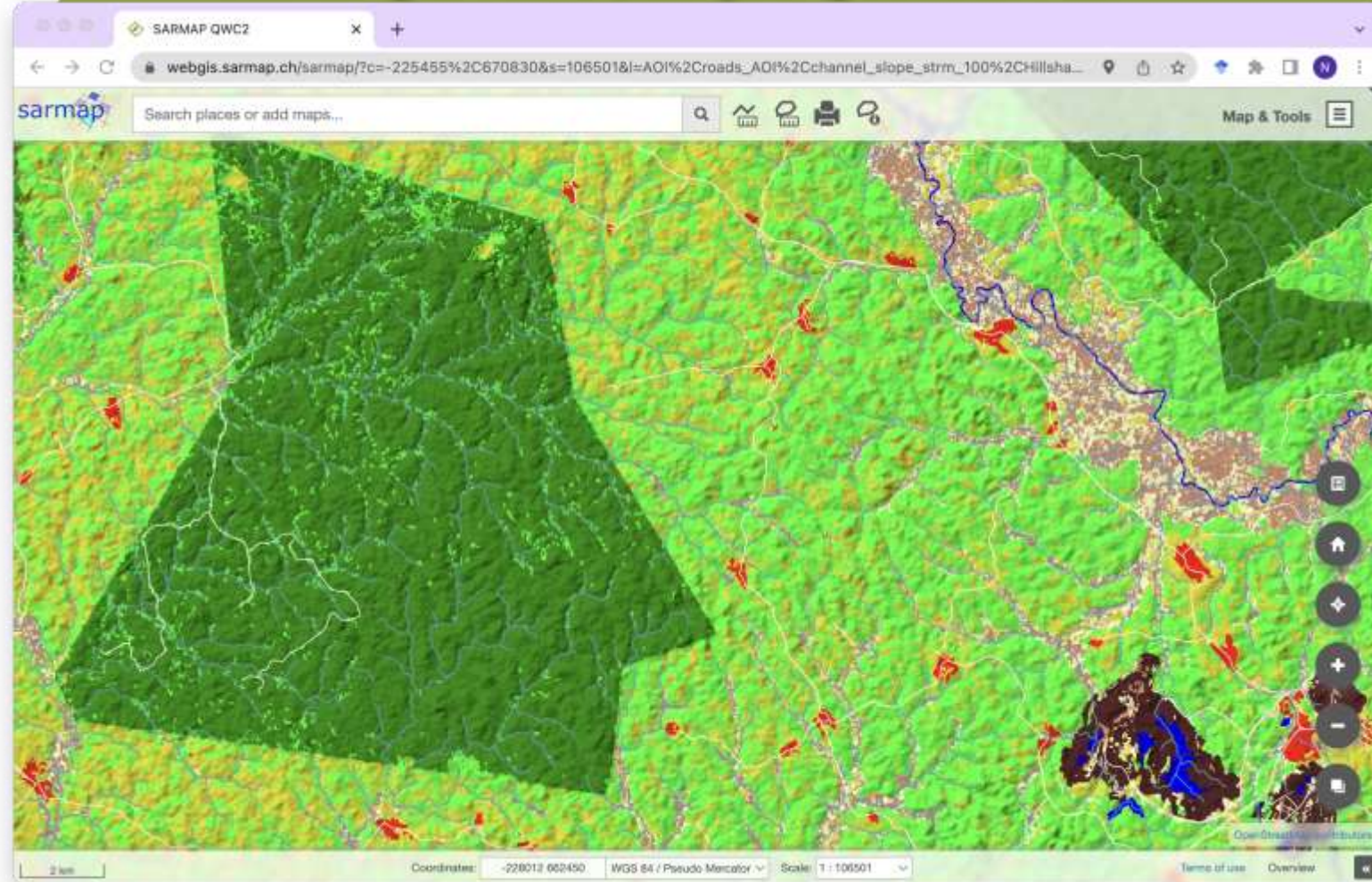




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## Results

**Mapping and Monitoring with Earth Observation Data  
(Satellites and Drone Images)**

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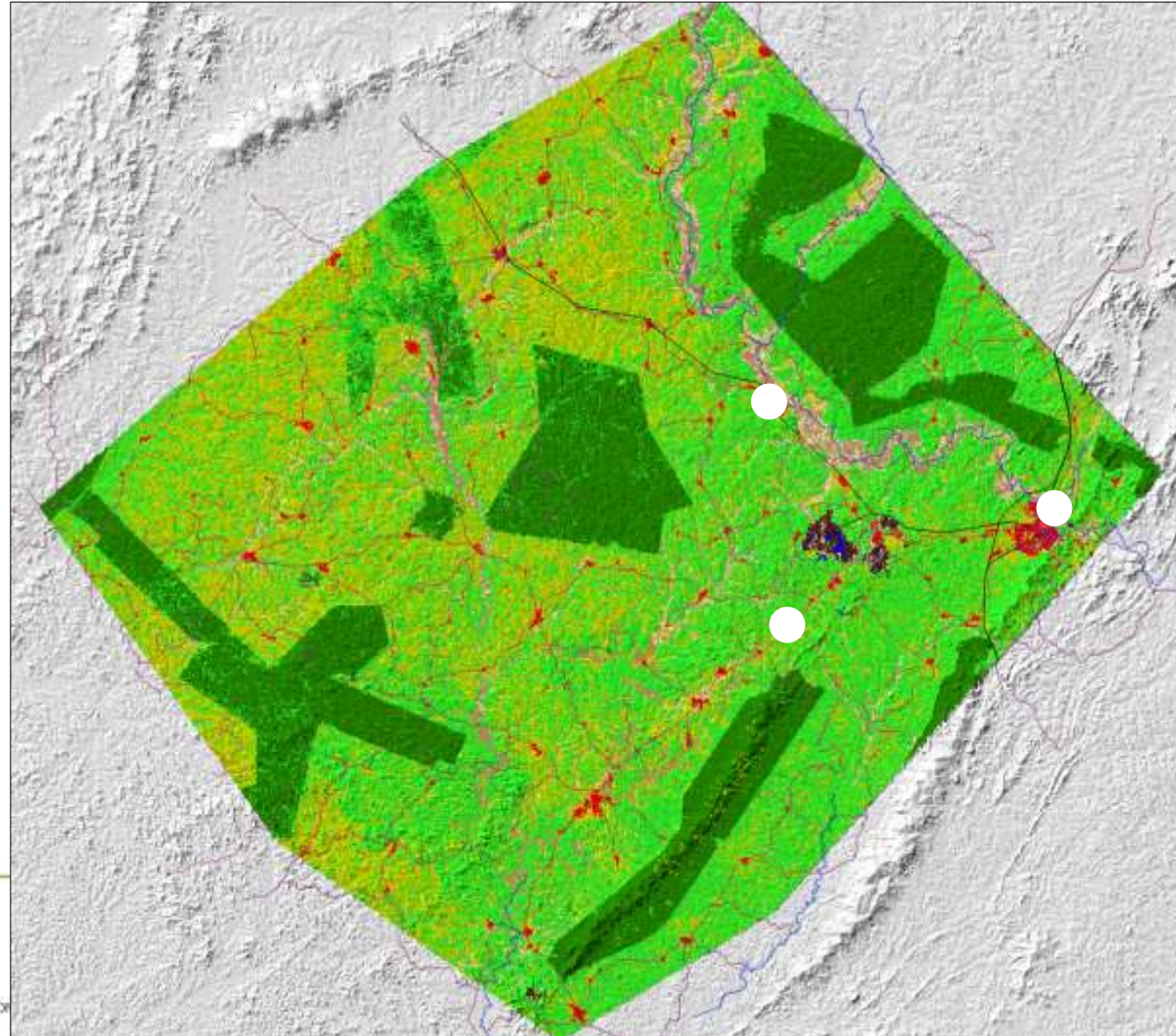
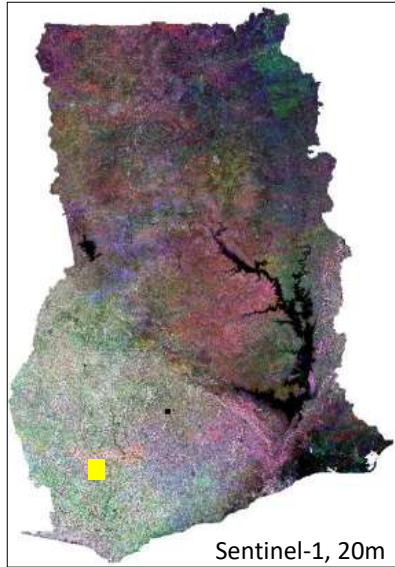
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## Legend

-  Forest reserves
-  Sparse vegetation
-  Industrial mining
-  Artisanal mining
-  Water
-  Settlements and infrastructures
-  Open areas
-  Bare soil

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Satellite Imagery



Drone on Satellite Imagery

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Satellite Imagery

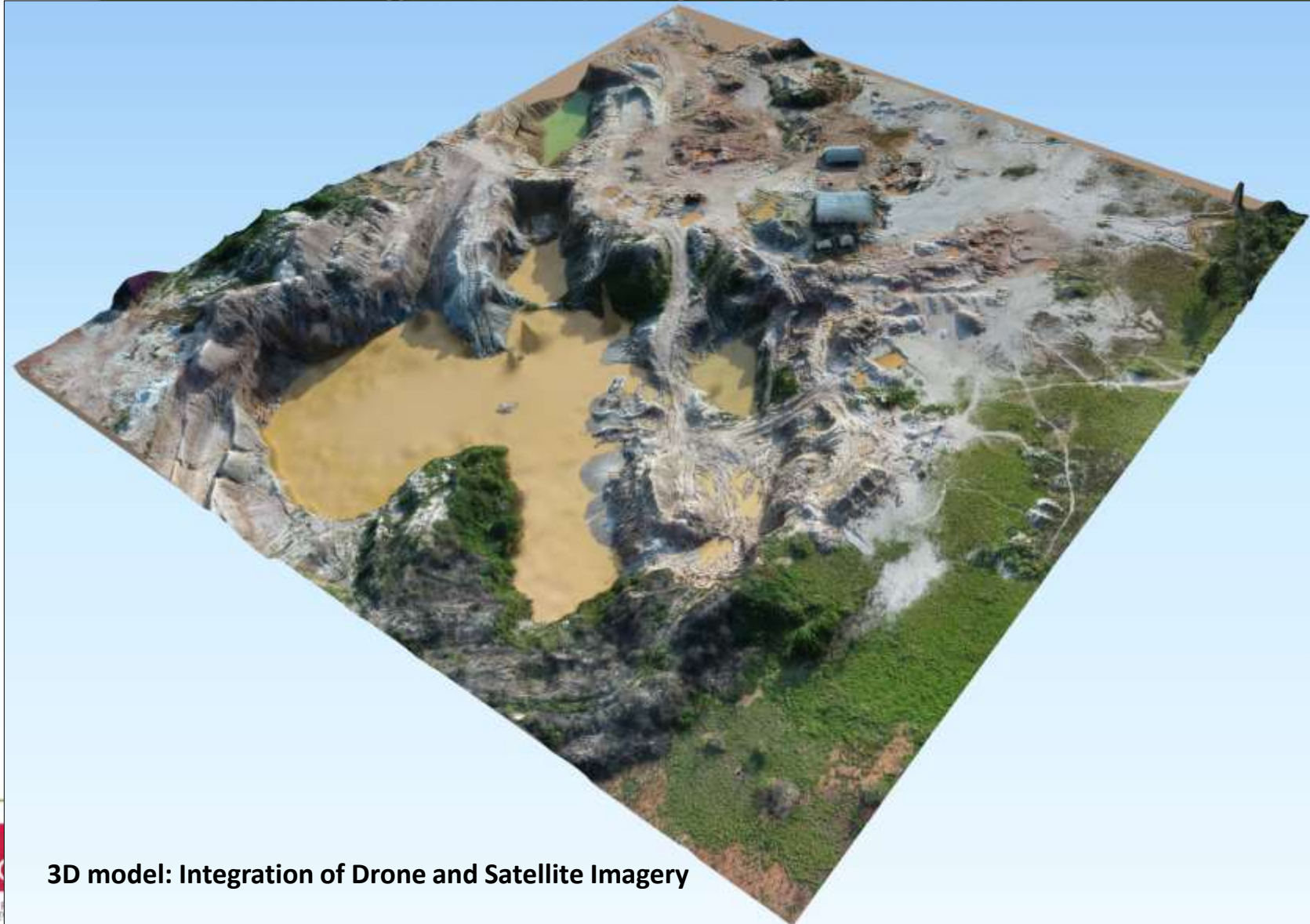


Drone on Satellite Imagery

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3D model: Integration of Drone and Satellite Imagery





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## Results

**Forest Disturbance Monitoring using SAR Data**

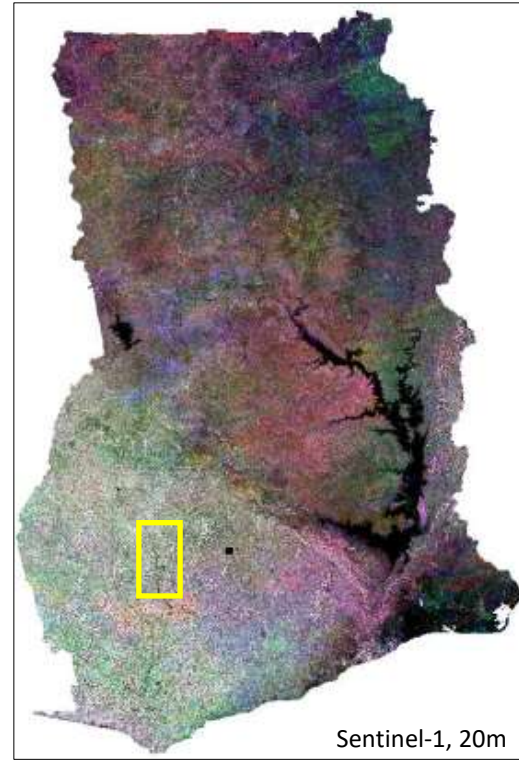
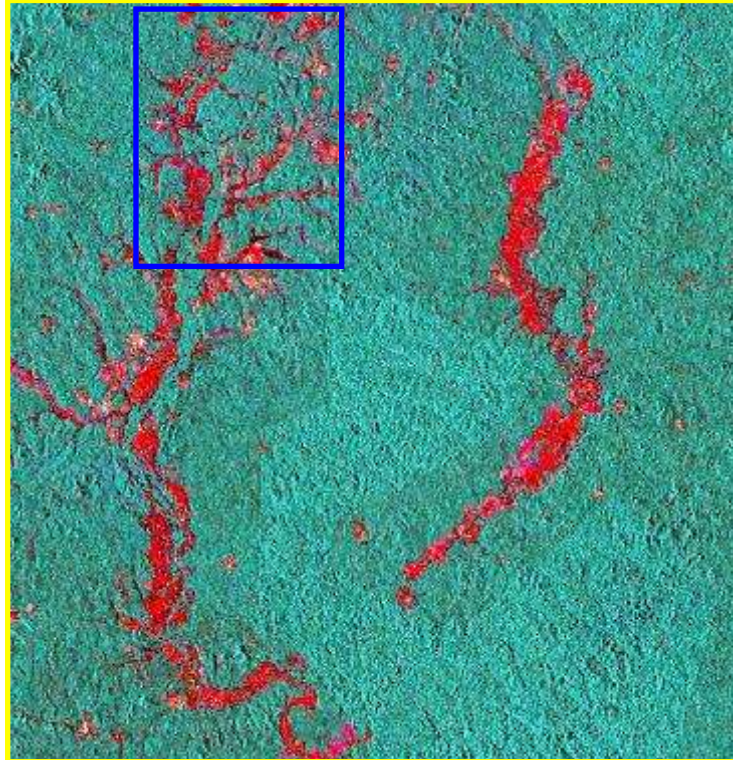
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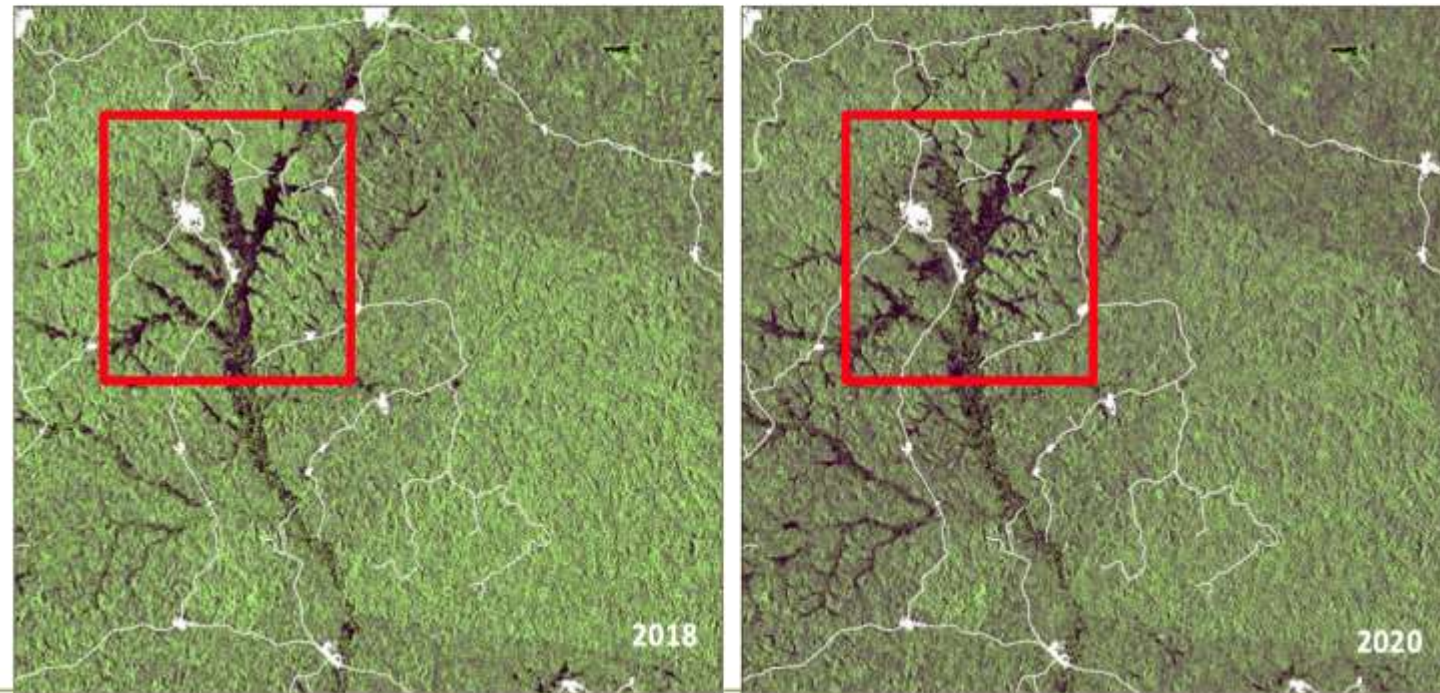
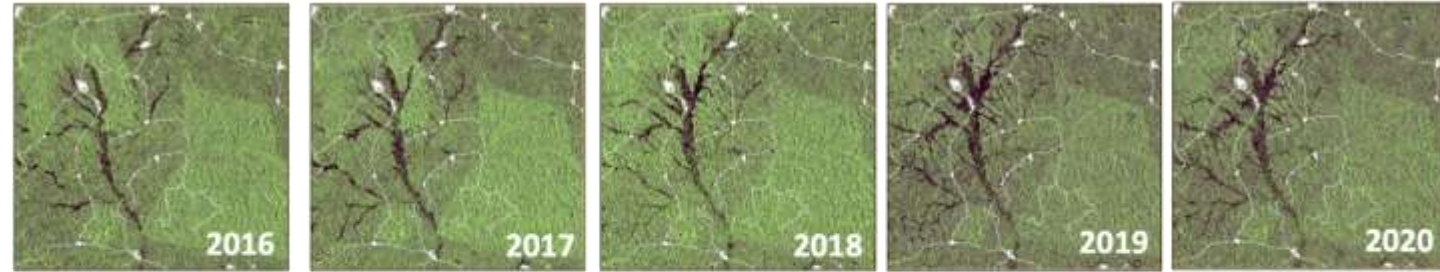
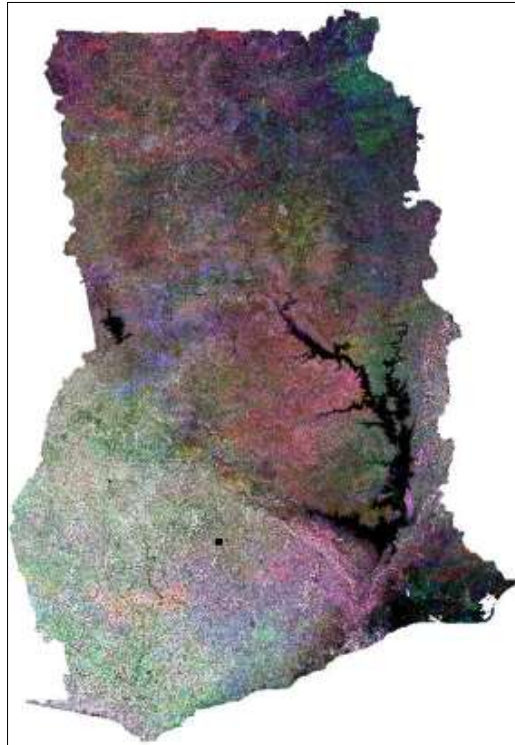
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## Results -



## Results

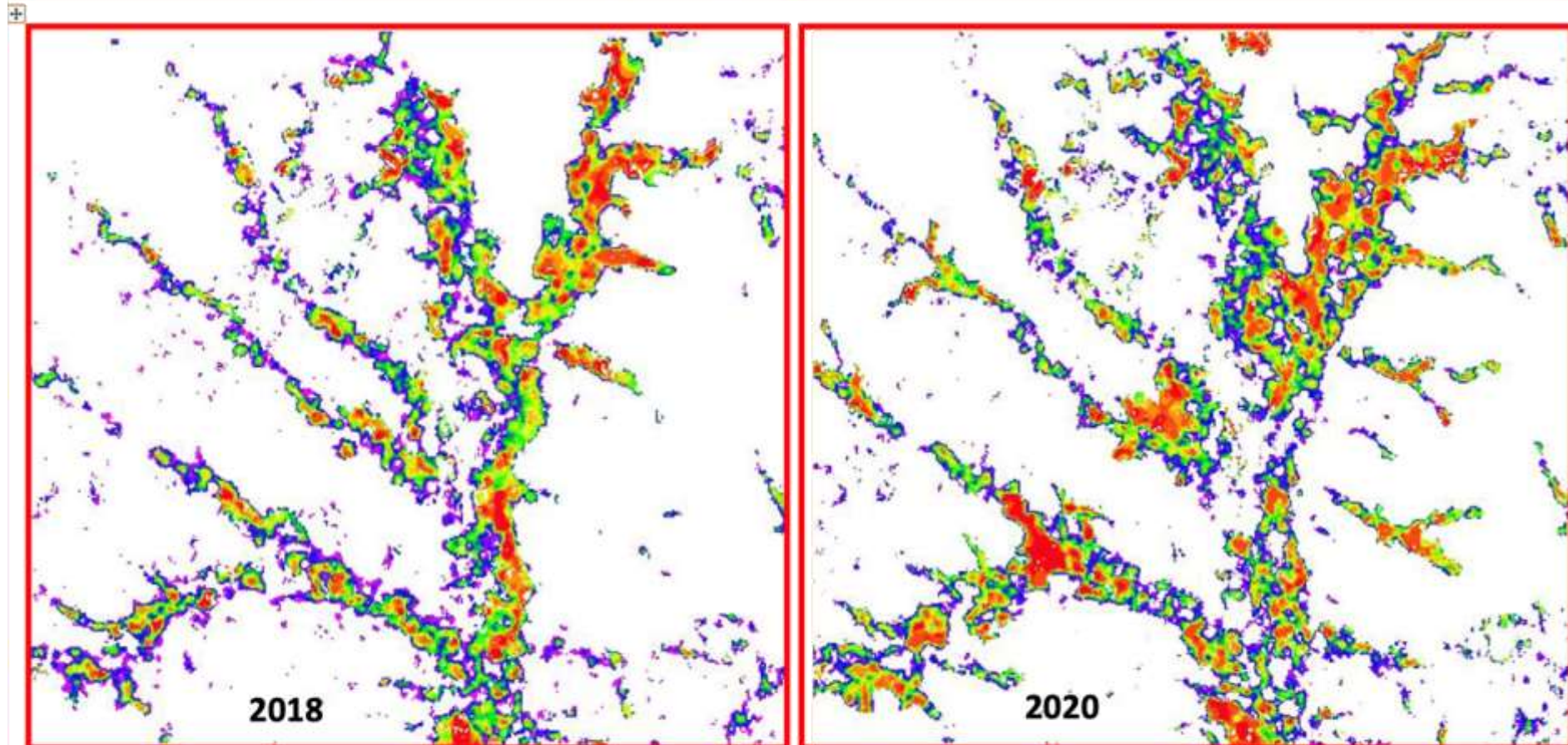
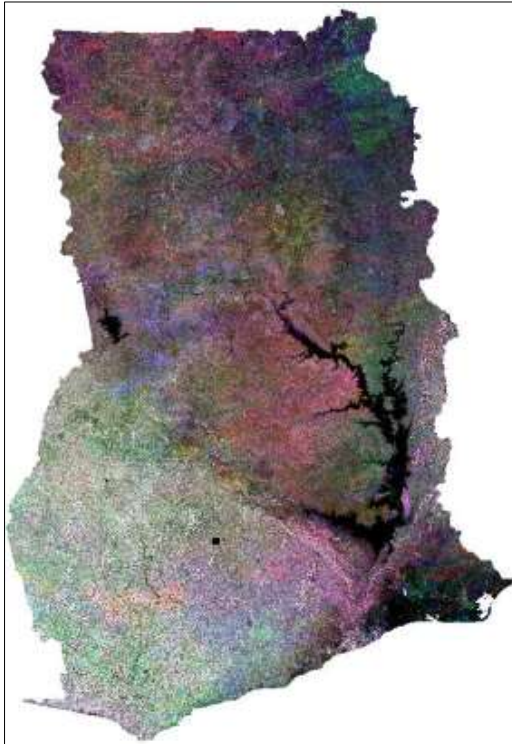


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## Results



no activity  continuous activity

## Results

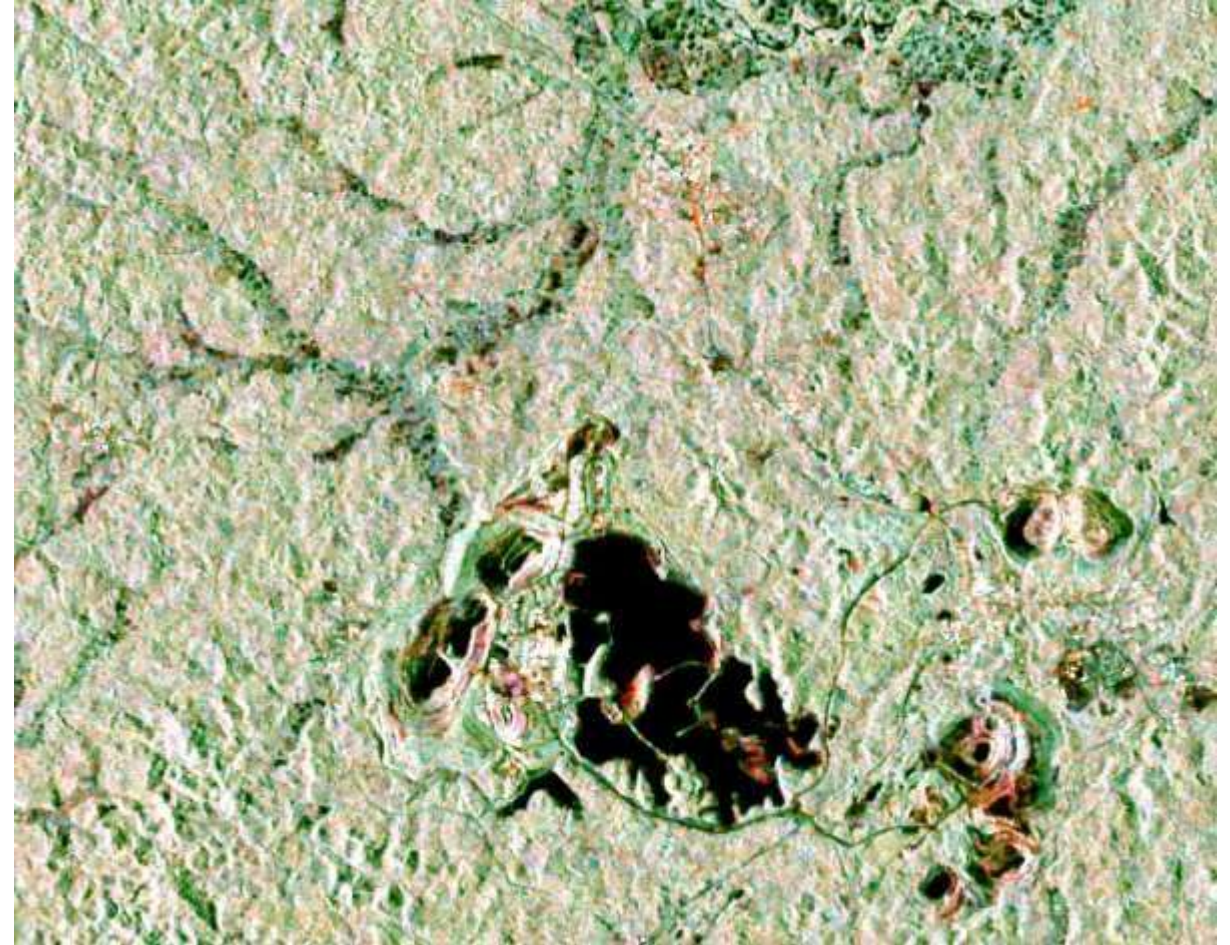
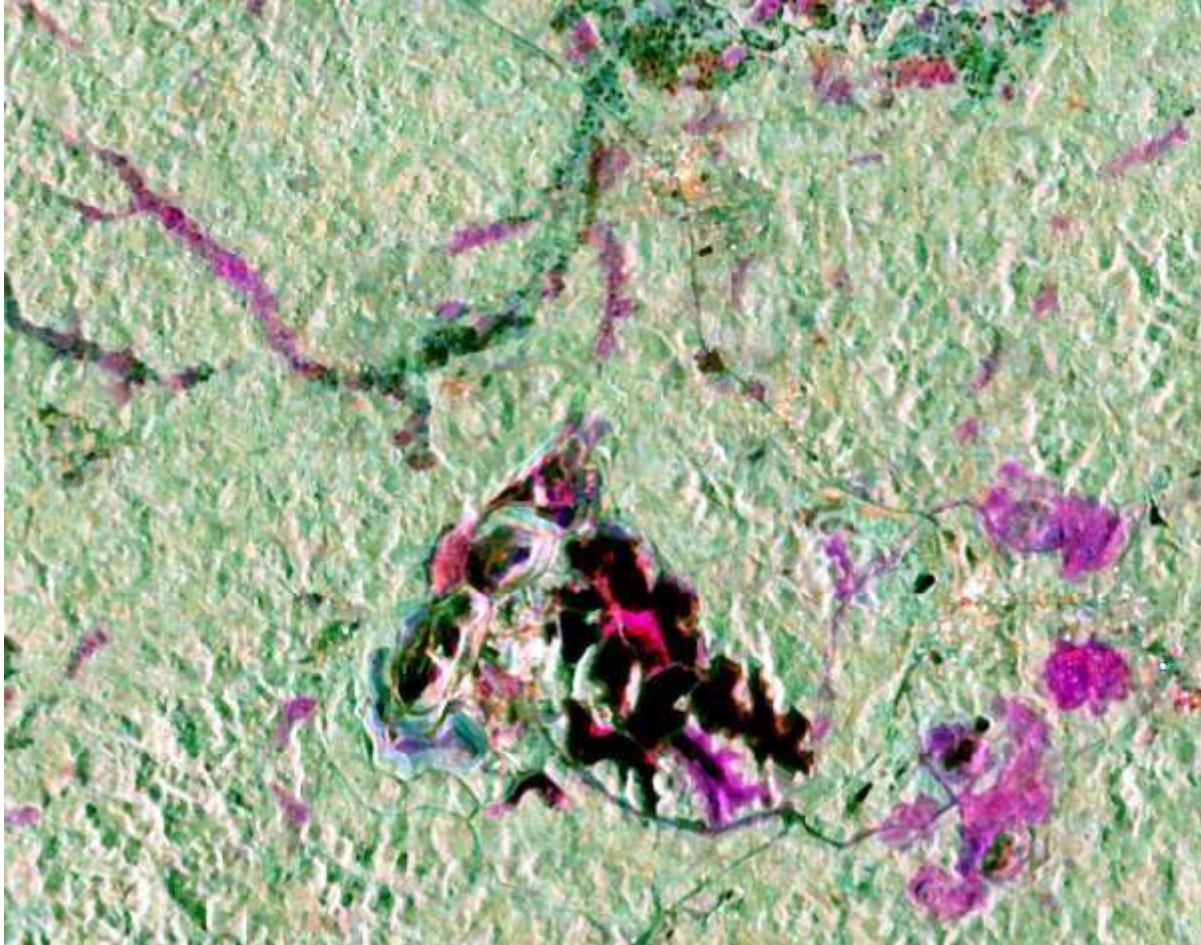
### Forest Disturbance Monitoring Using SAR Data (Close to a regulated mining site)



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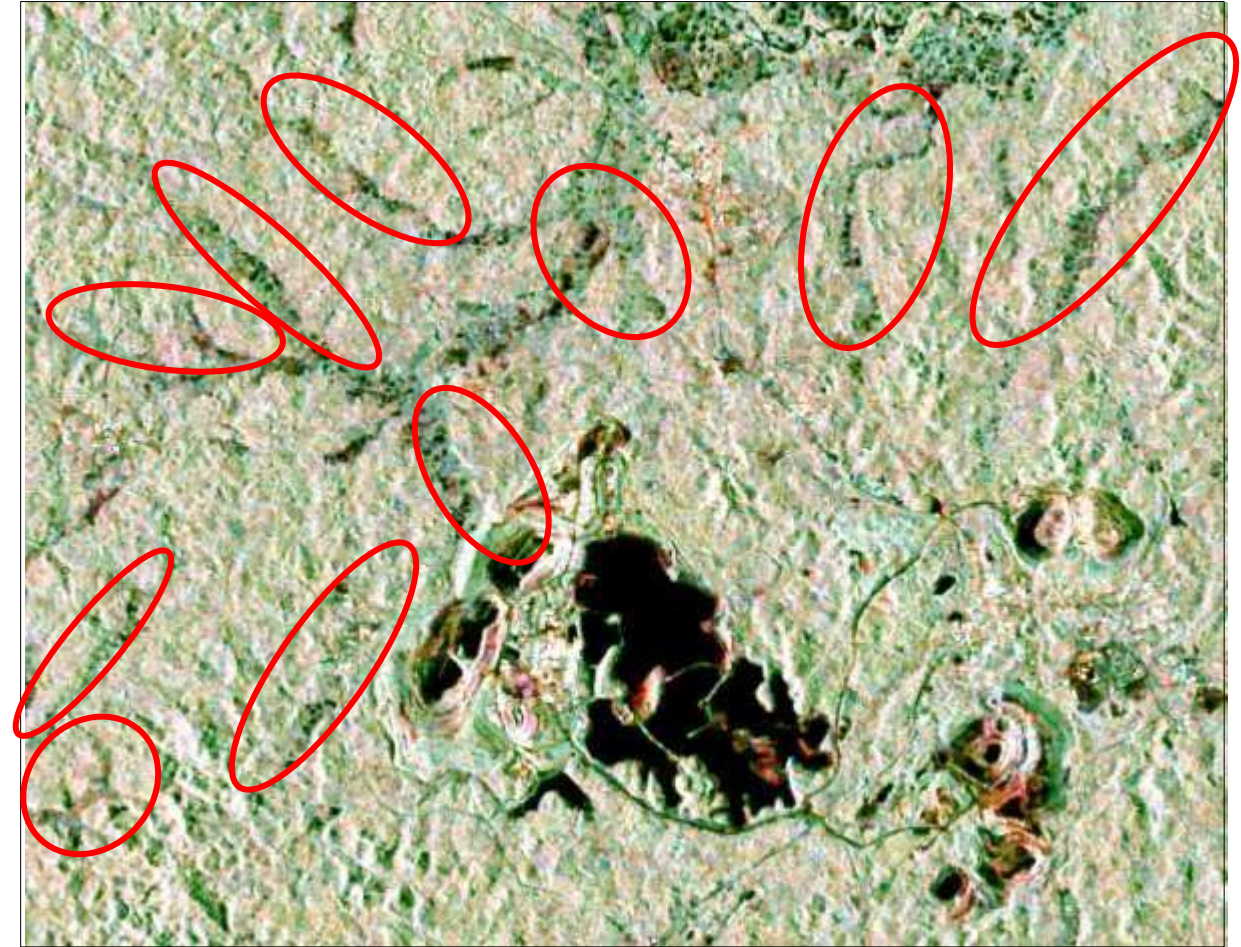
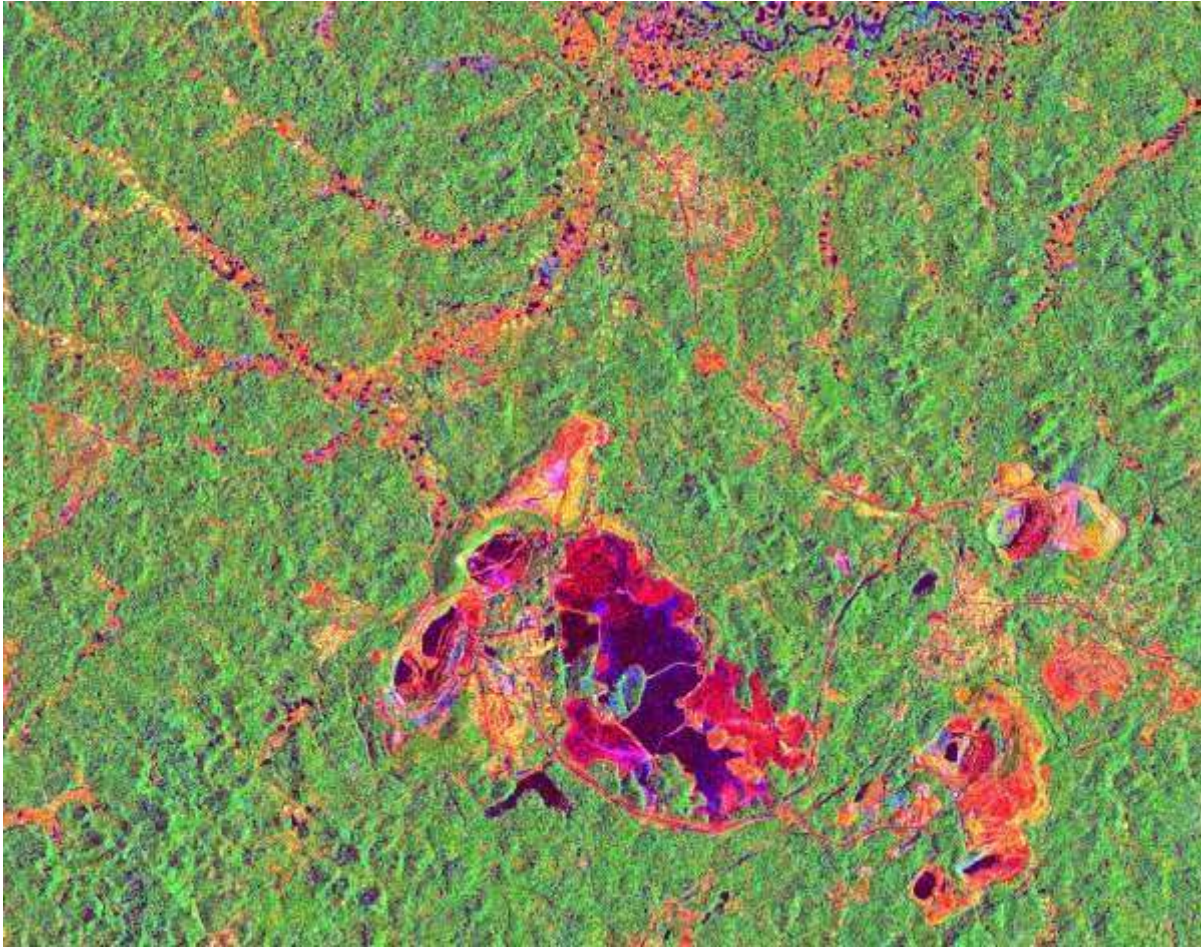
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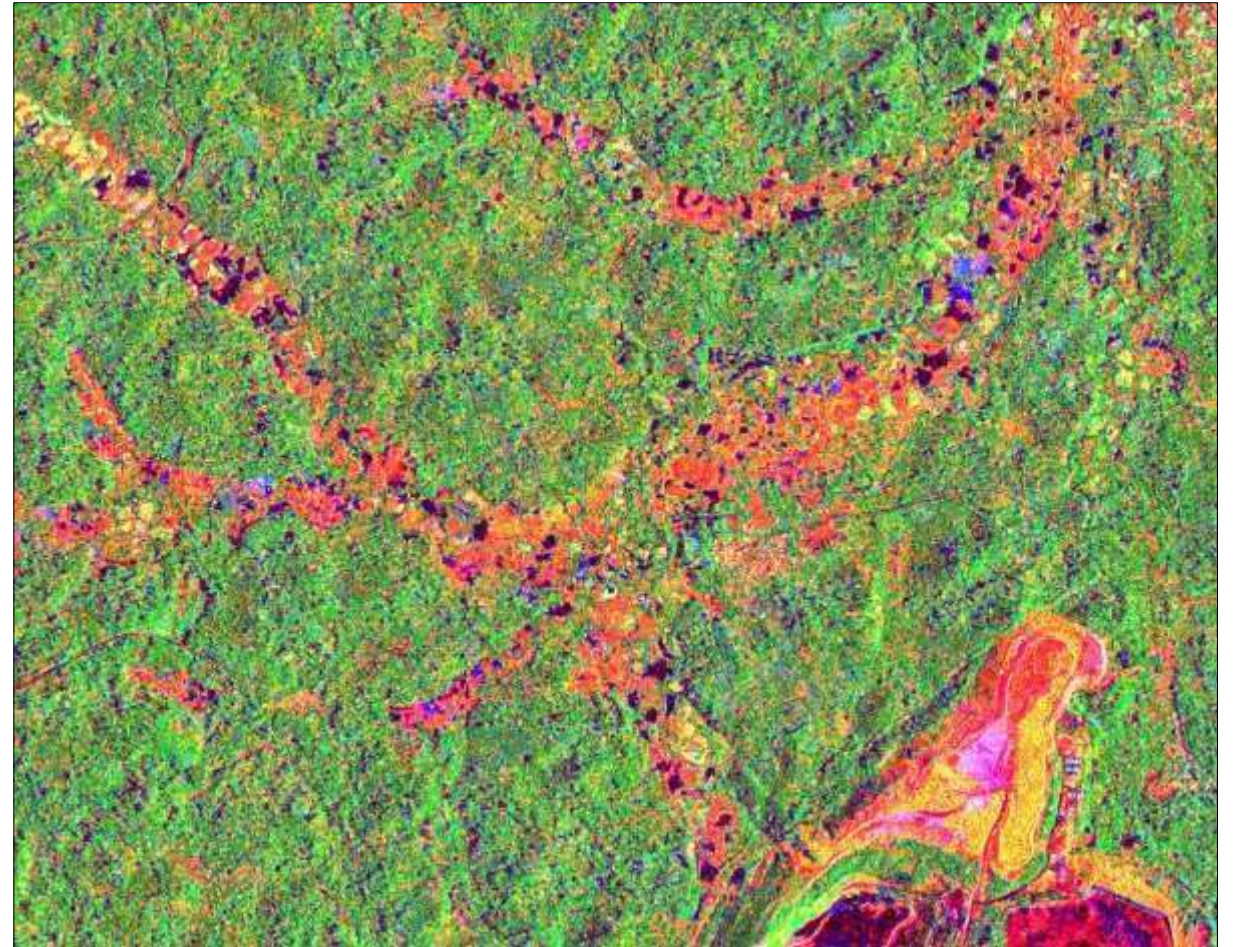
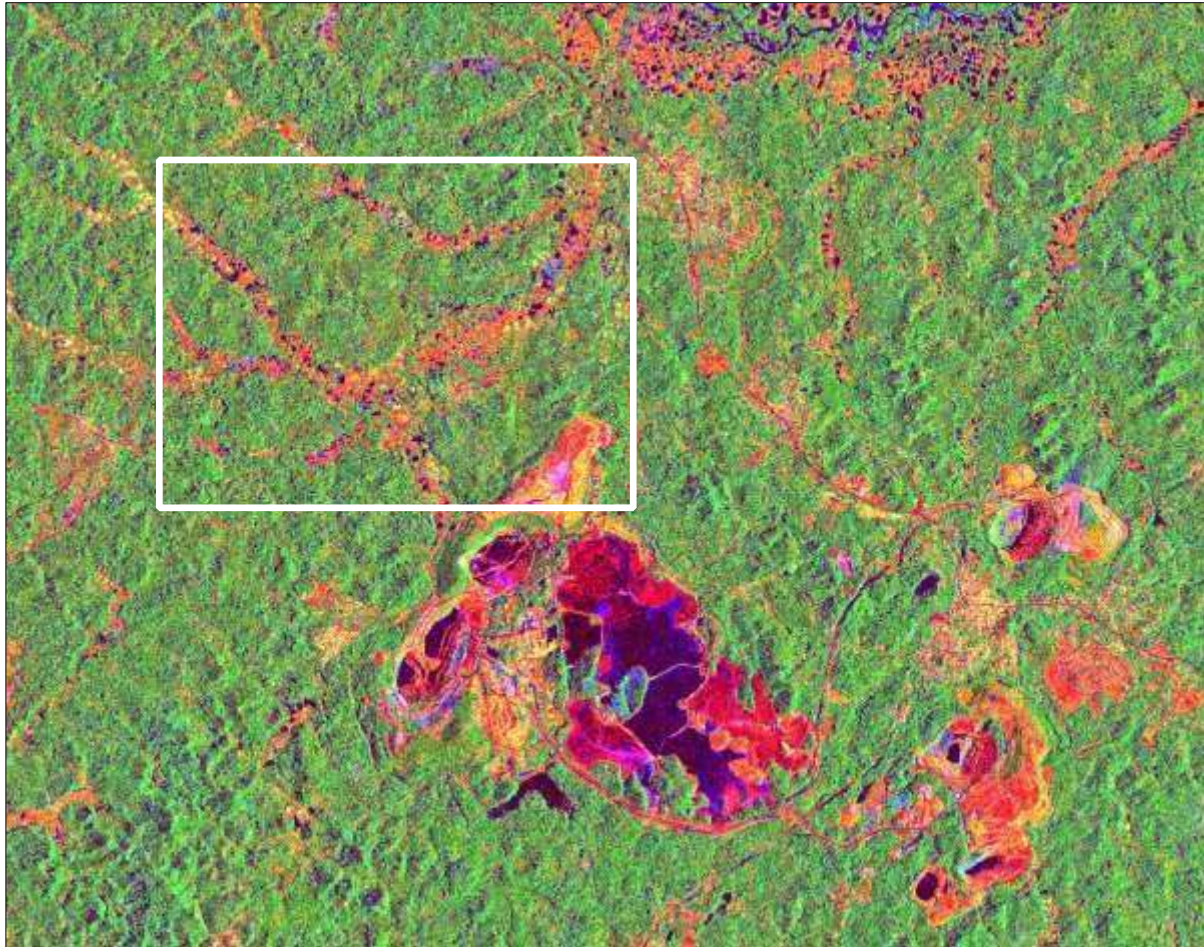




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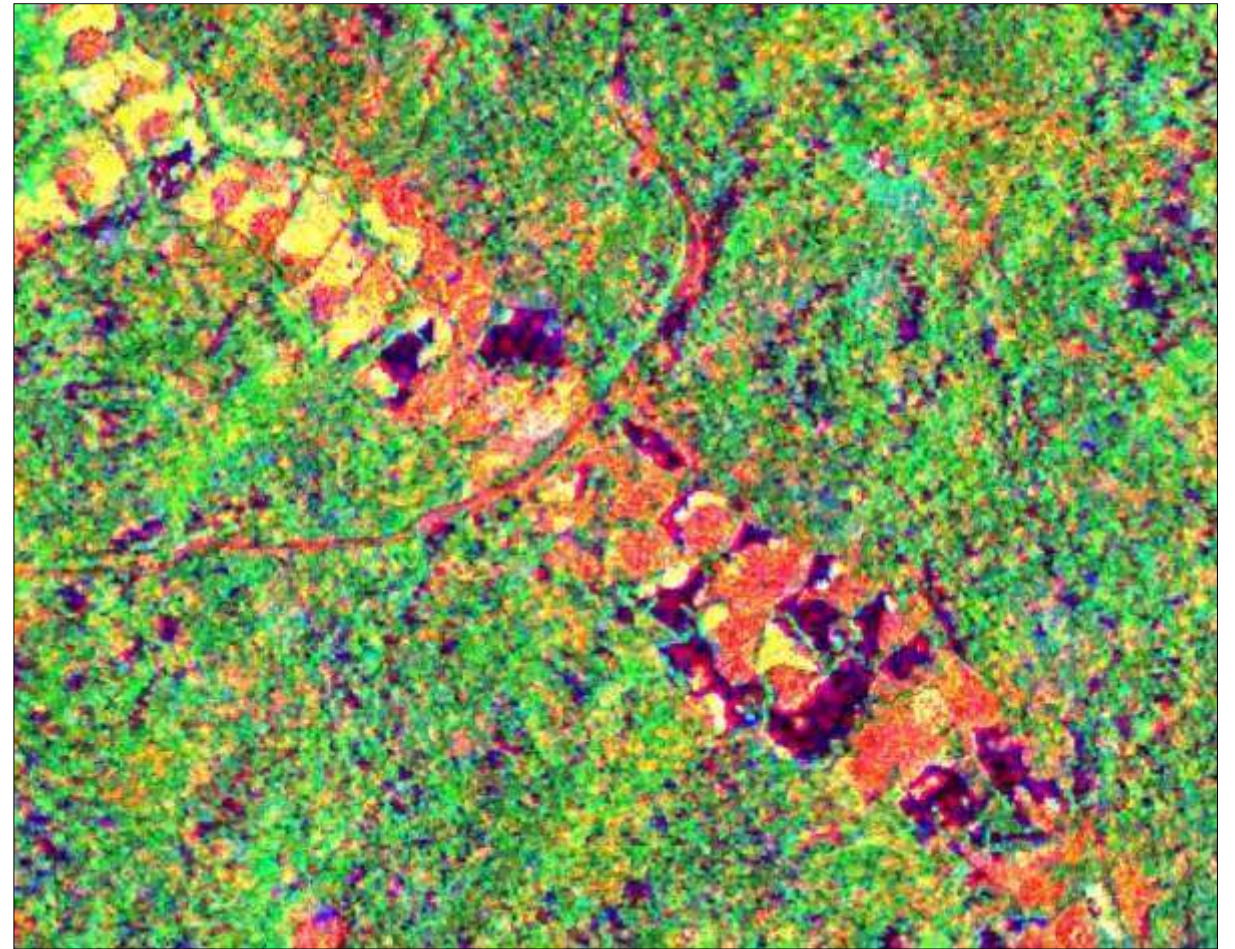
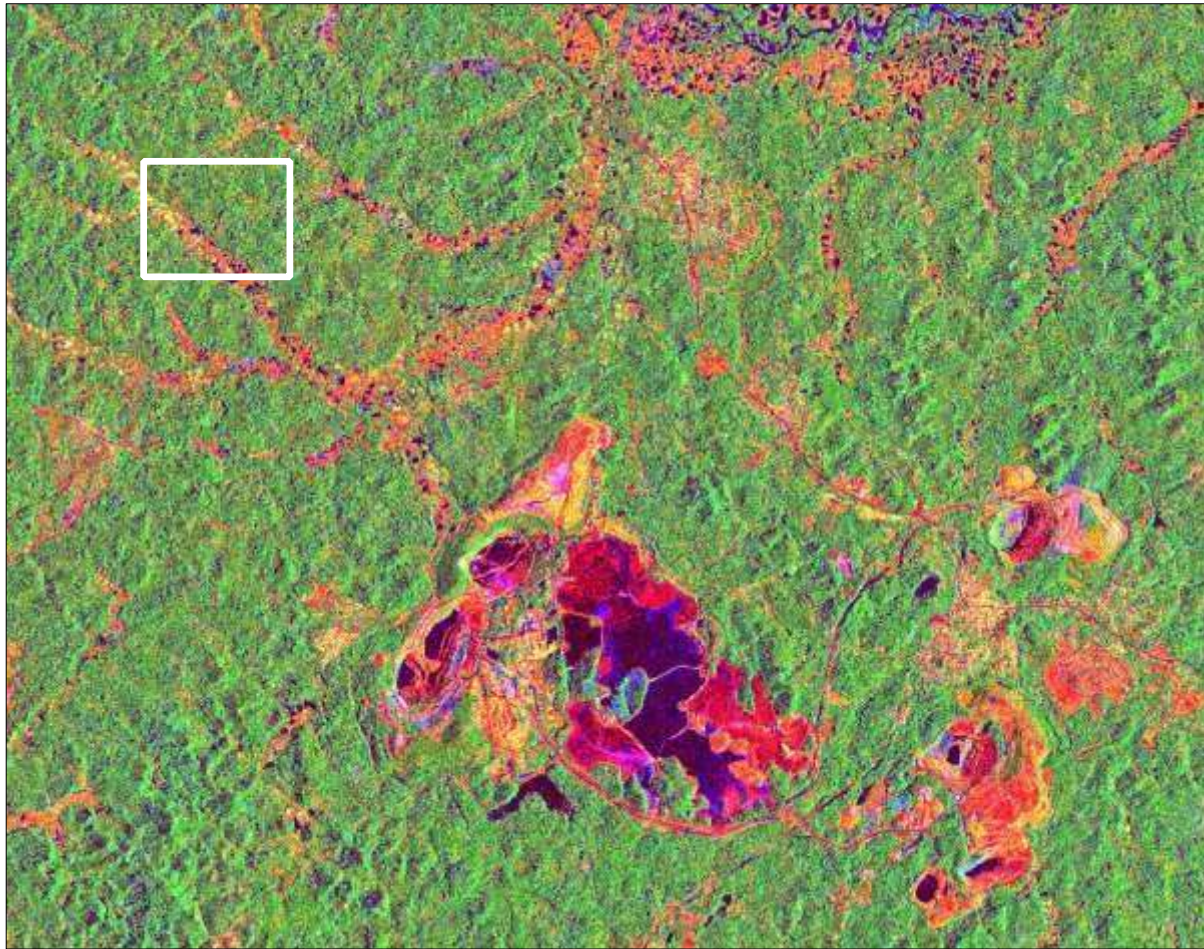




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## Results

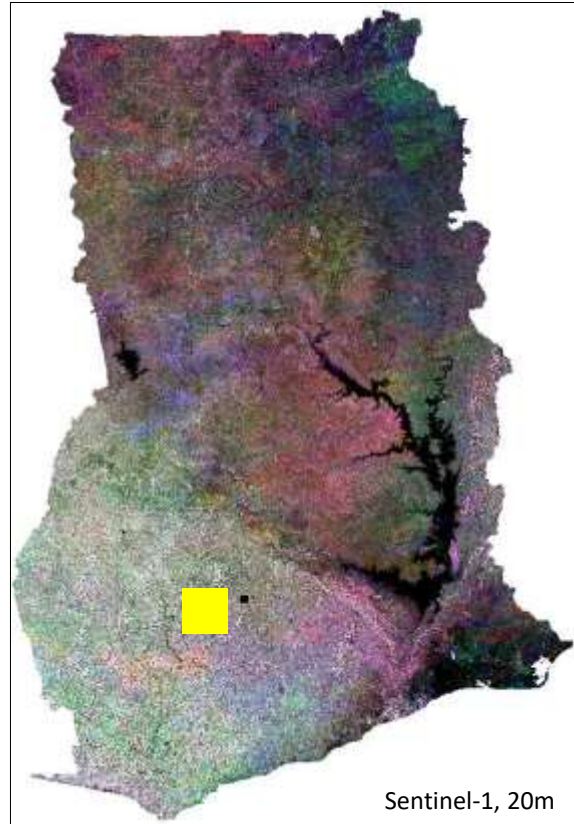
# Apamprama Forest Reserve



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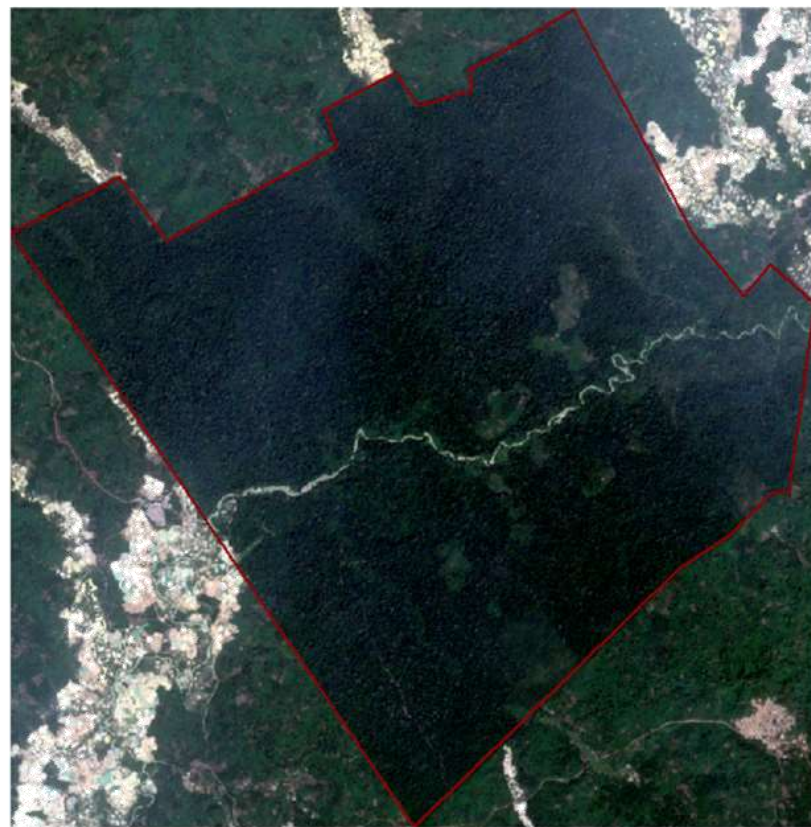
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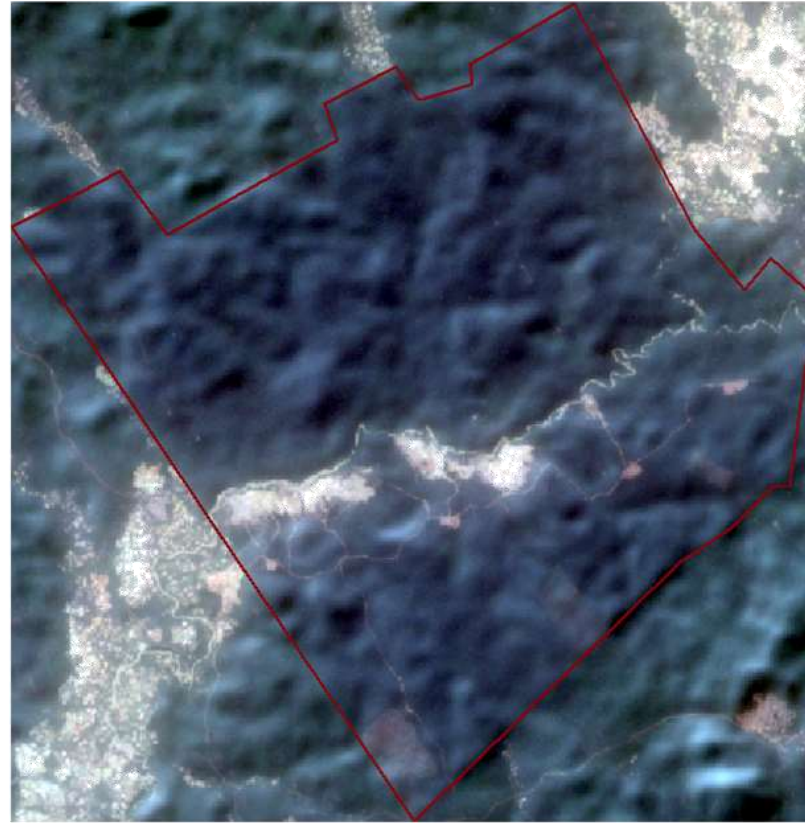
Sentinel-1, 20m



## Apamprama Forest Reserve



**2017 - 0 % Forest Loss**



**2019 - 5 % Forest Loss**



**2022 - 30 % Forest Loss**

## Conclusion

- Early warning systems help to detect unregulated mines leading to reduced environmental impact, and protection of forest reserves, habitat, and biodiversity.
- From the demonstration project, it was observed that open-source satellite data with moderate spatial resolution ranging from 10-30 m and temporal resolution spanning 6-16 days were adequate for monitoring purposes.
- High-resolution satellite and UAV data with a spatial resolution of 3 m or better are suitable for mapping purposes.
- Full deployment of the customised remote sensing service will help determine which forest reserves are threatened and require priority conservation efforts.