Early Warning System using a multi-sensor Disturbance Index

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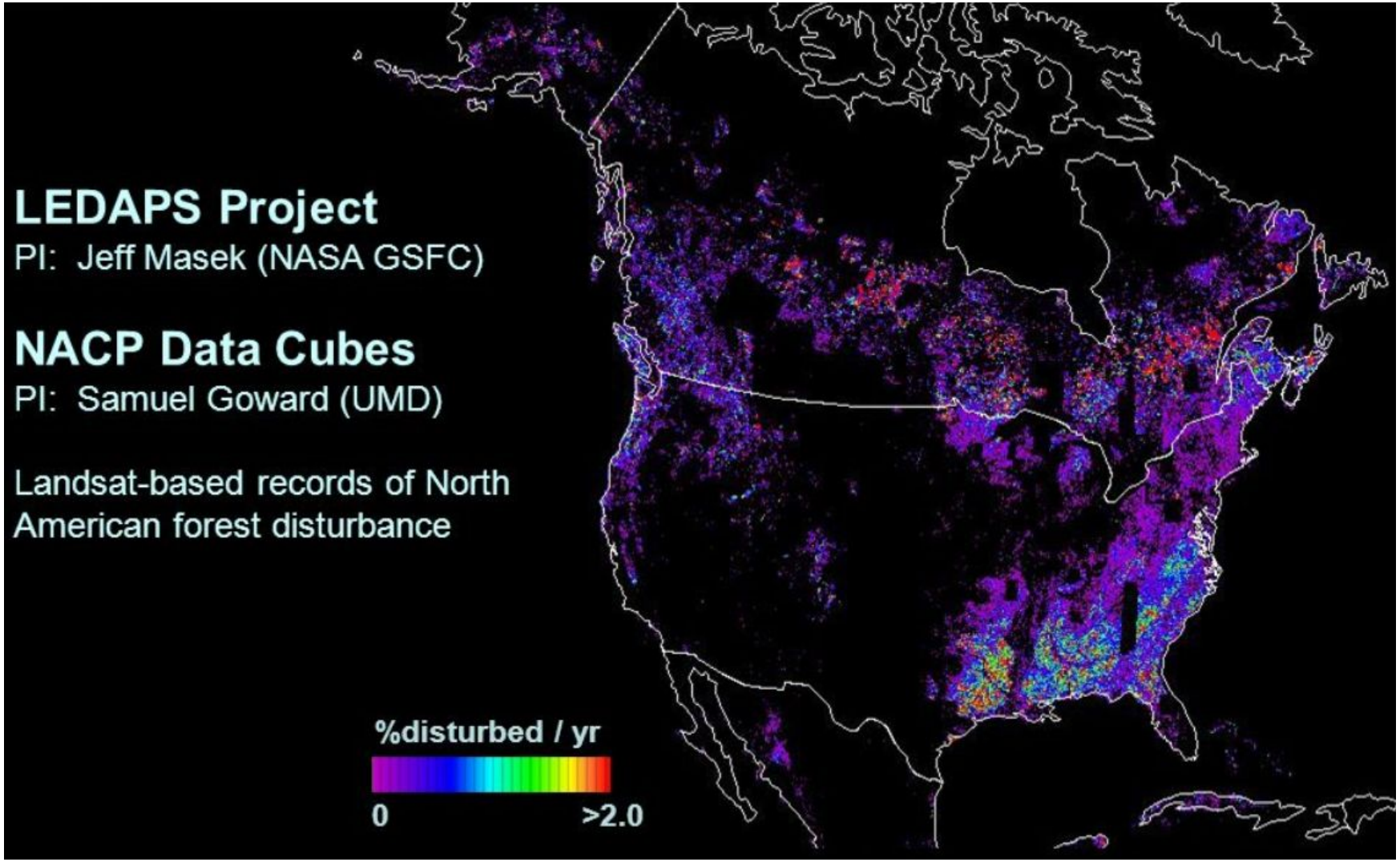
Alerting Systems must be:

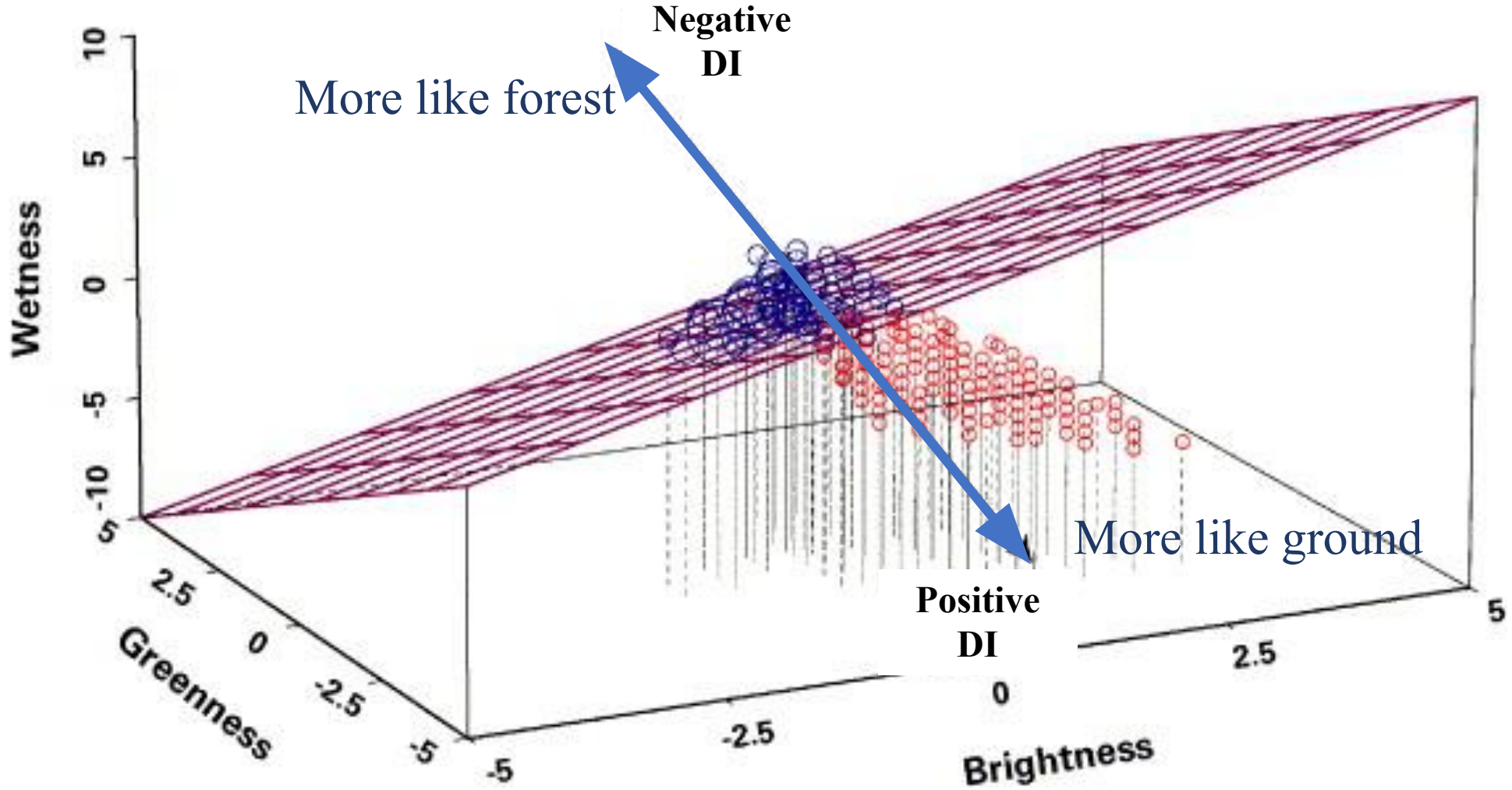
- **Accurate (particularly with low false positive error)**
- **Timely**
- **Intuitive**
- **Automated**
- **Low-bandwidth, low-hardware**

Landsat Disturbance Index (DI_L) – simple and effective transformation of Landsat data that highlights forest loss over time

30 meter mapping of forest loss with 2004 technology



The Disturbance Index compares the reflectance of each pixel to the average condition of nearby forests, expressing it in standard deviations above (toward ground) or below (toward really dark forest) the mean



Healey et al., 2005

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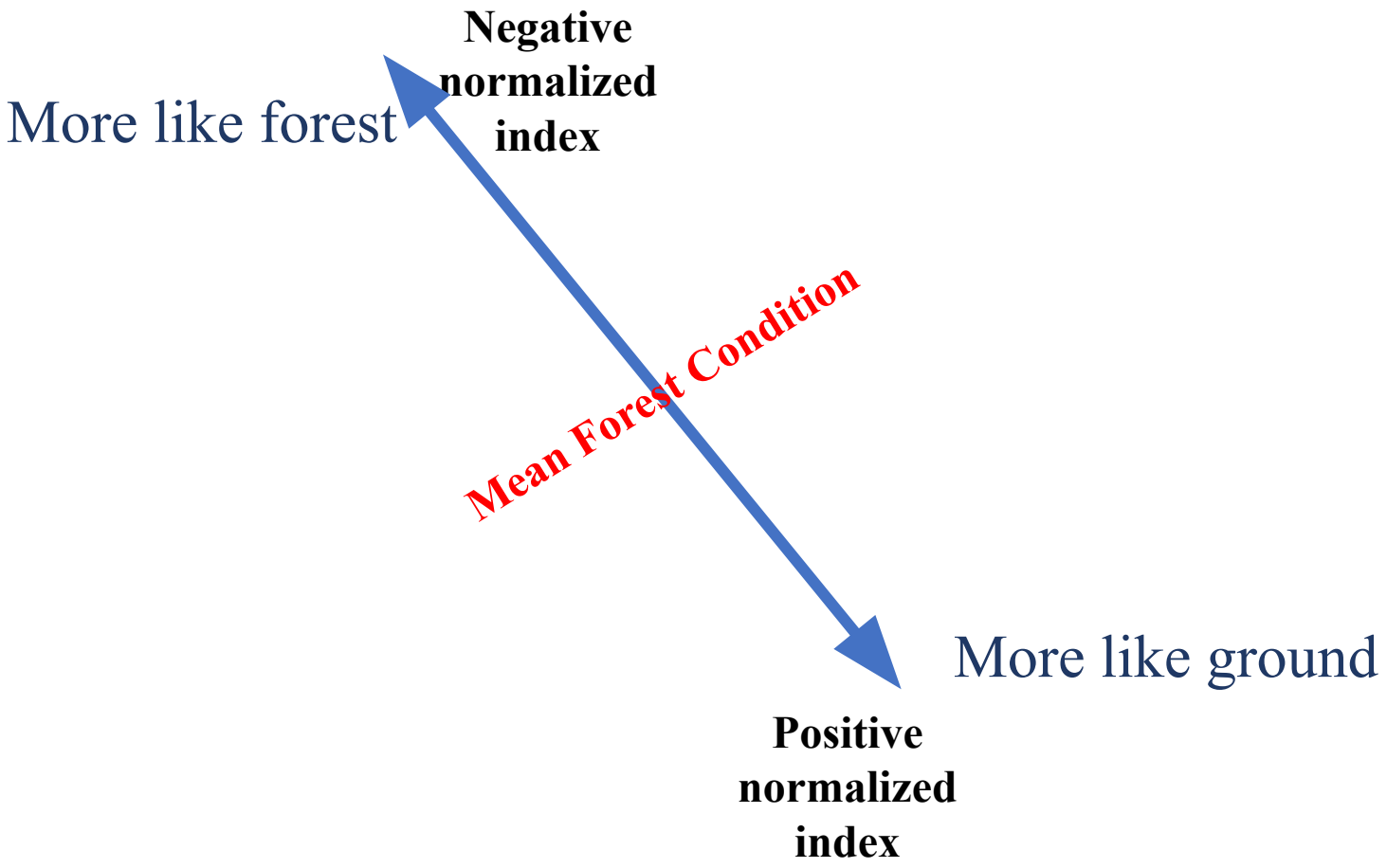
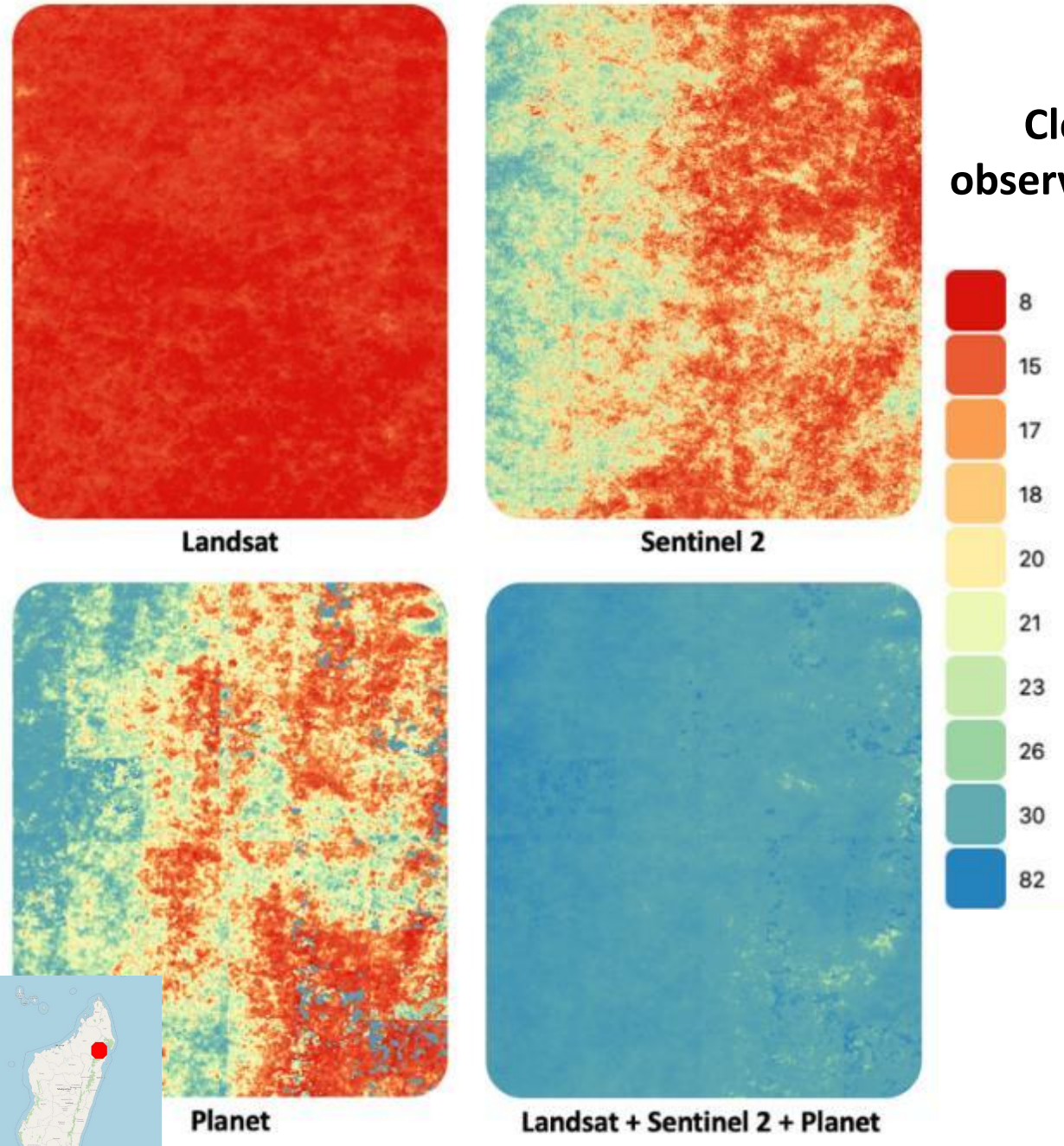


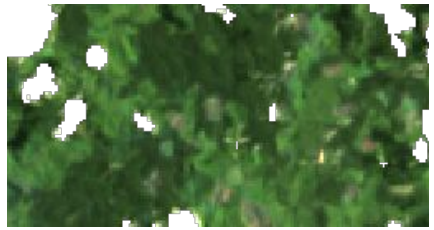


Motivation for using multiple sensors in one of the world's cloudiest places

Multi-Sensor Disturbance Index

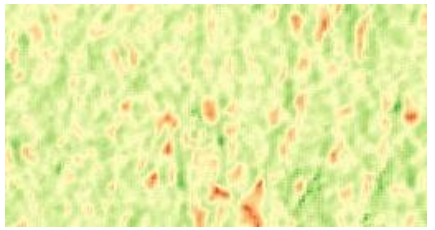
1. Reflectance or backscatter data

Landsat (3/1/2020)



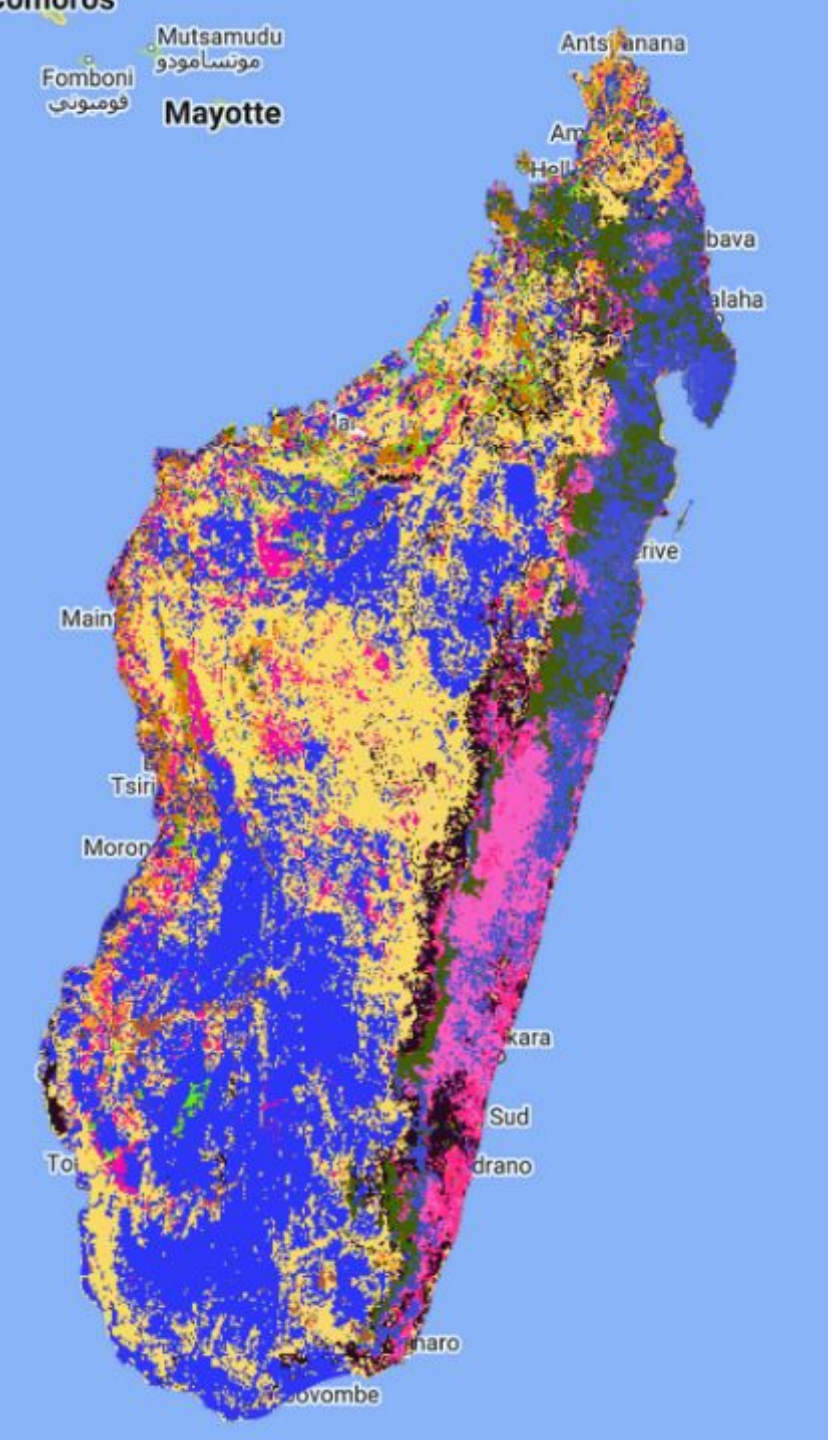
Sentinel-2 (12/12/2019)

Sentinel-1 (12/21/2019)

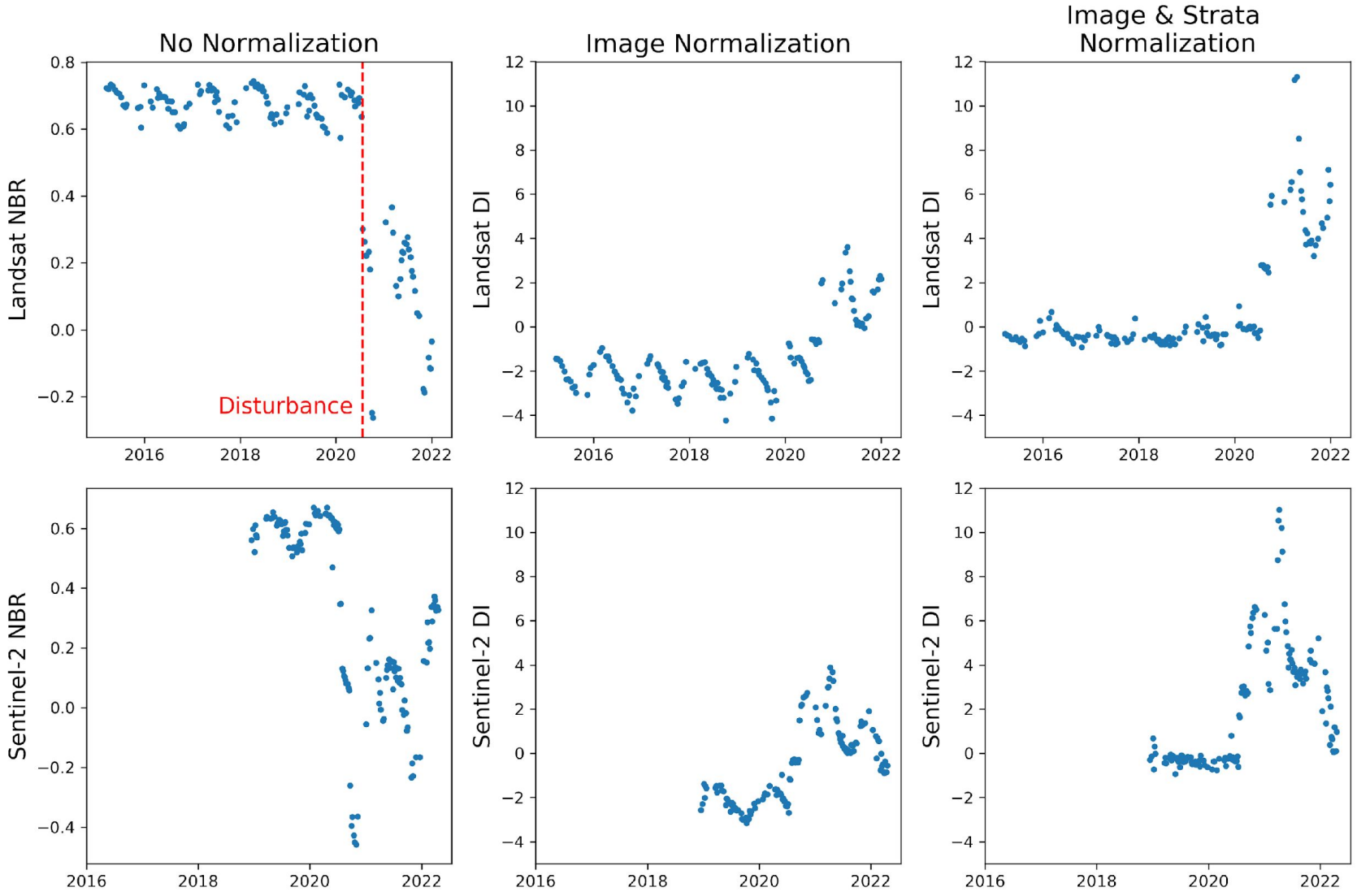


Planet (10/26/2019)

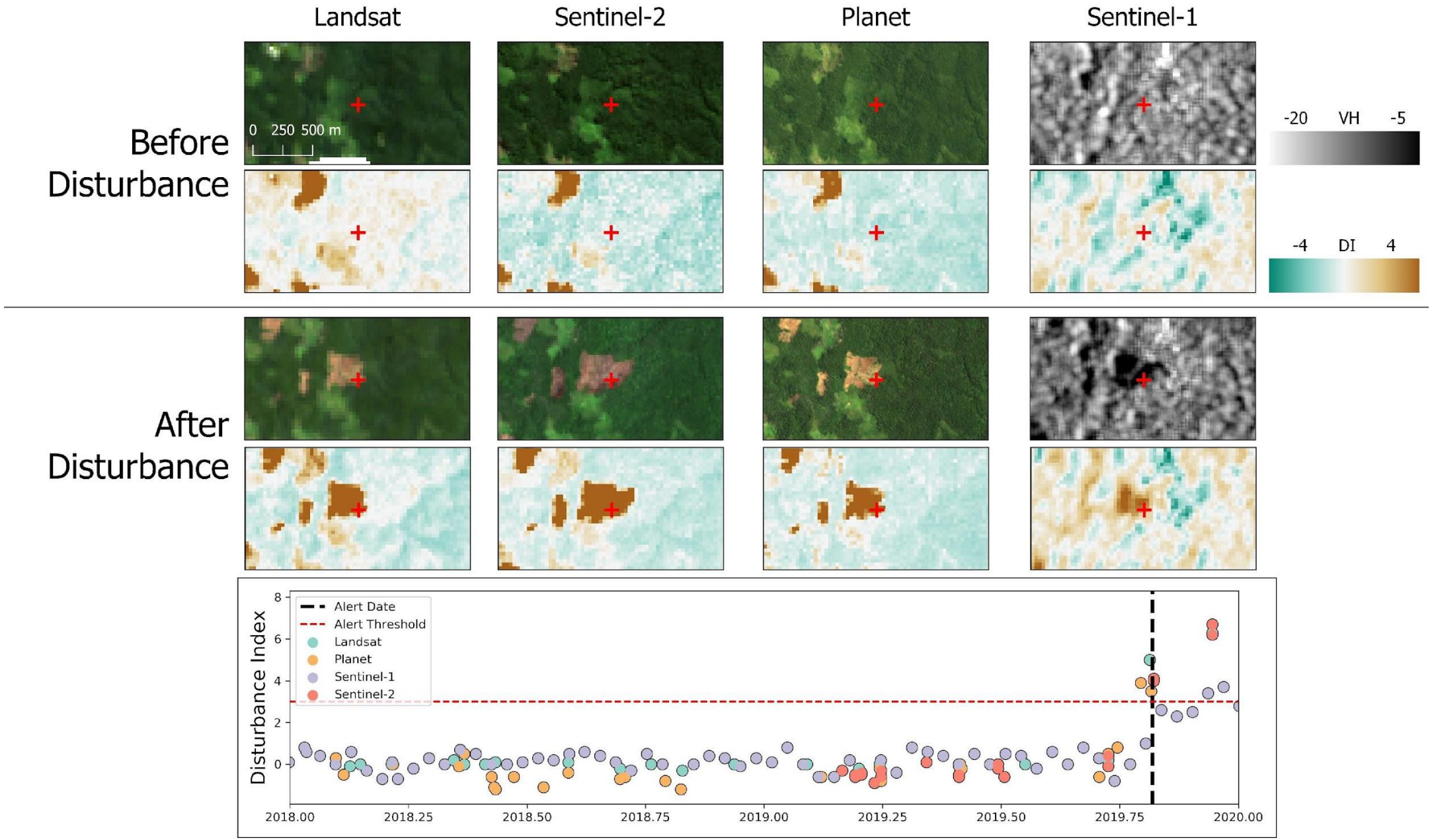
$$DI_{NBR} = \frac{X_{NBR} - \mu_{NBR}}{\sigma_{NBR}}$$



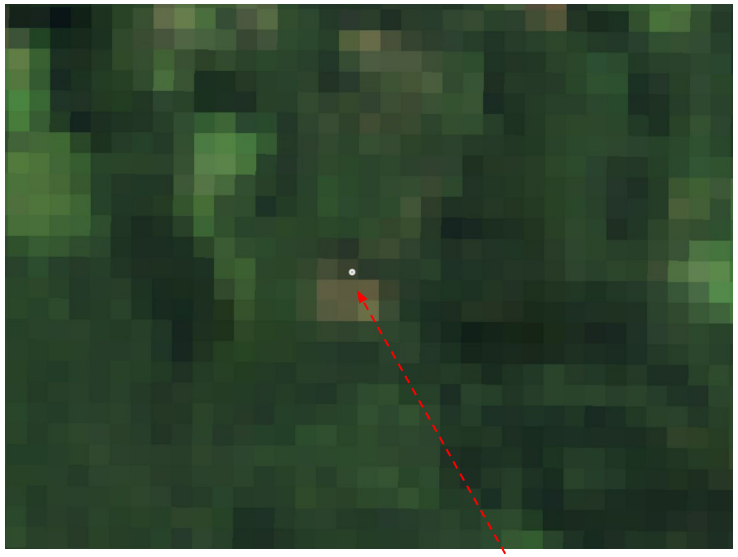
Normalizing by forest population with similar seasonal characteristics reduces seasonal effects



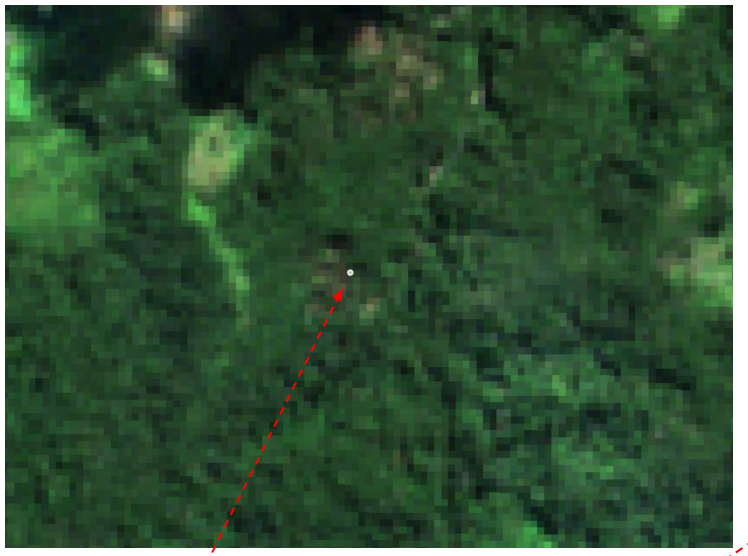
Combining DI_L, DI_{S1}, DI_{S2}, and DI_P



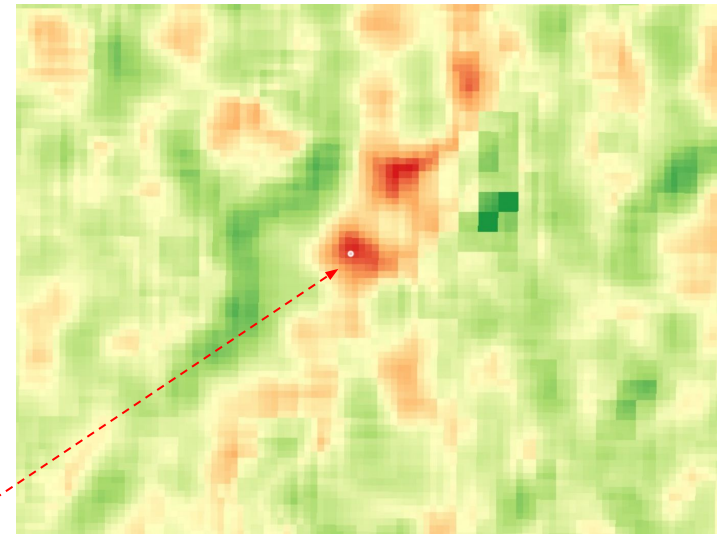
Landsat RGB 6/14/2020



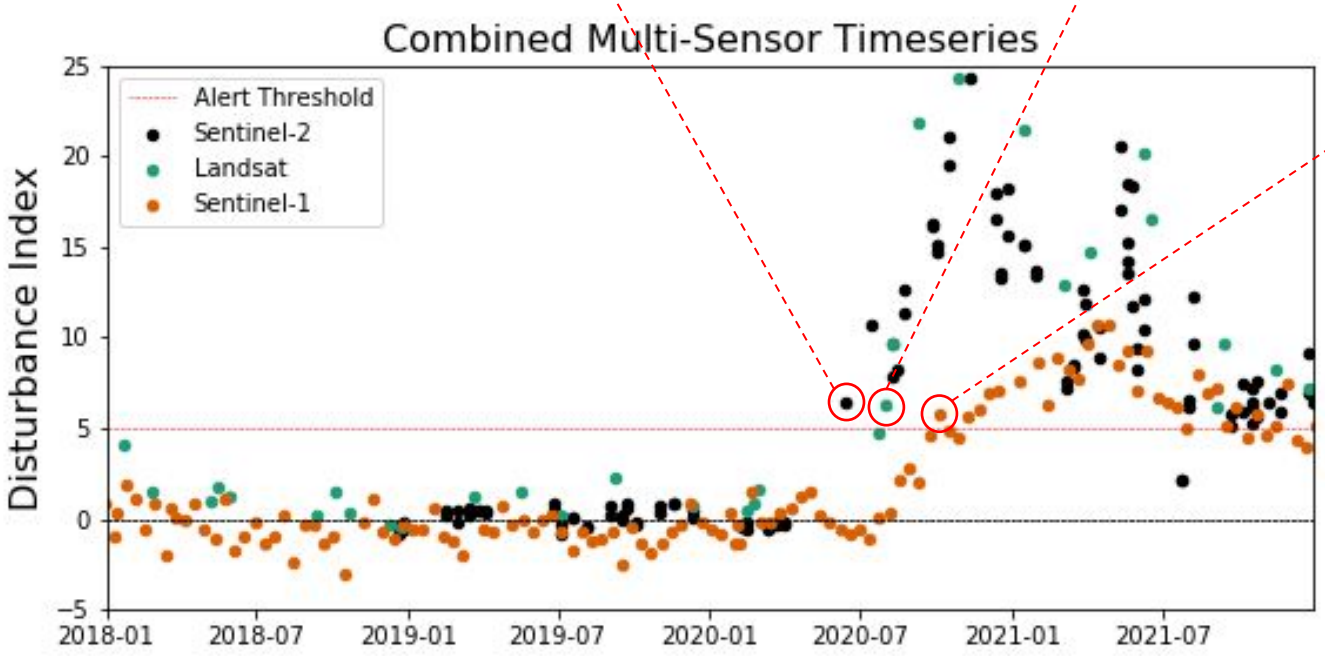
Sentinel-2 RGB 8/8/2020



Sentinel-1 VH 10/4/2020

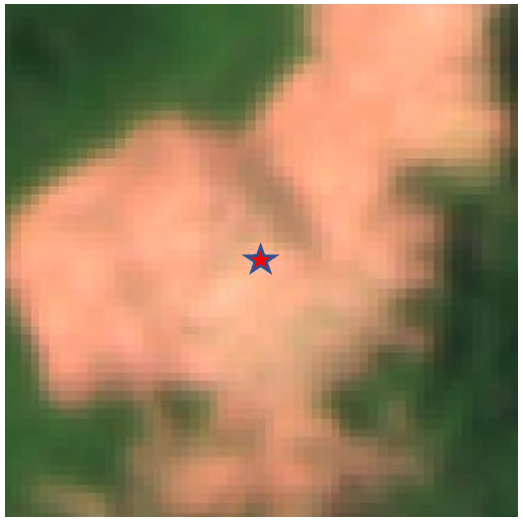


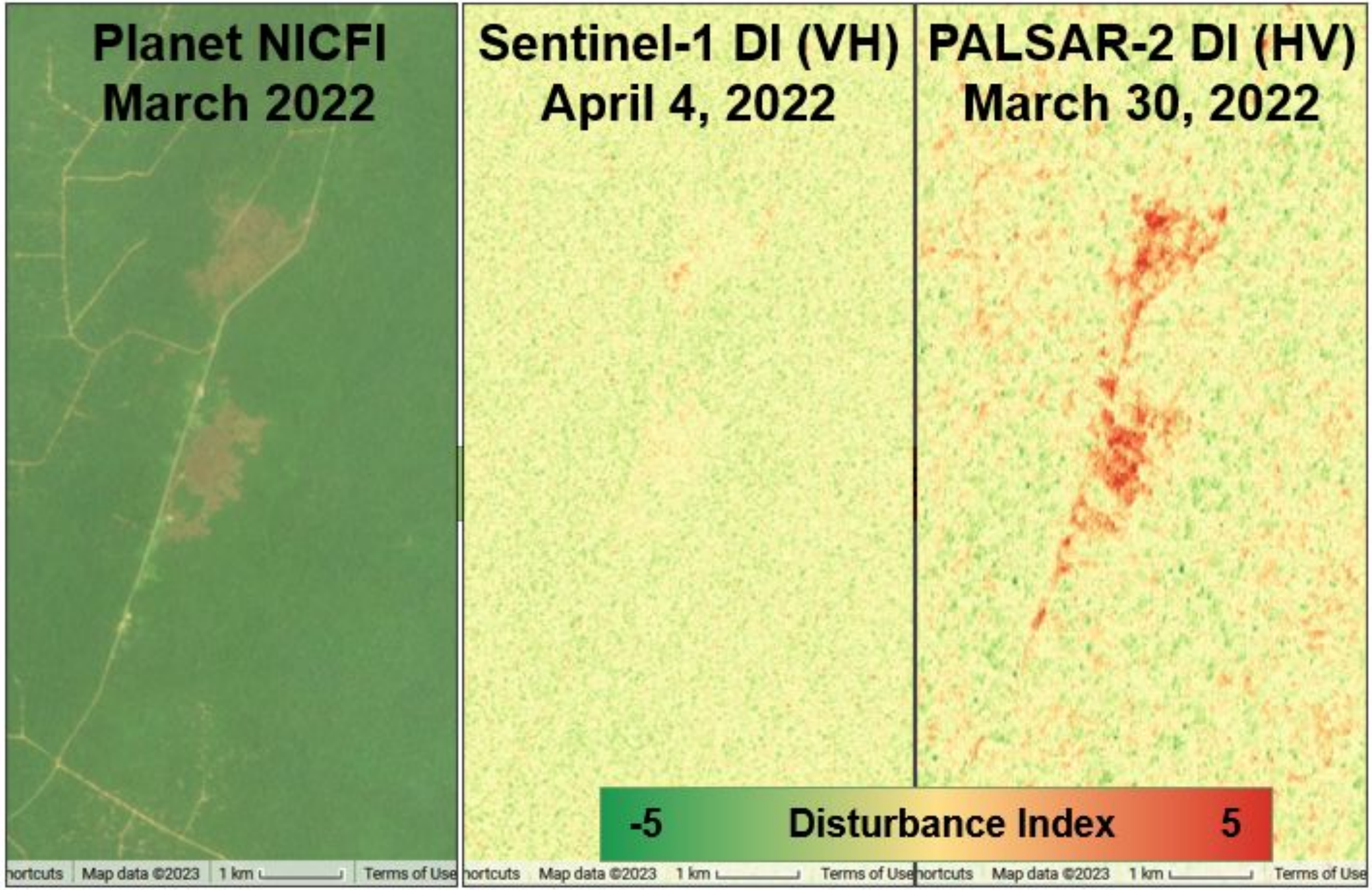
Stretch: Red -> Yellow -> Green



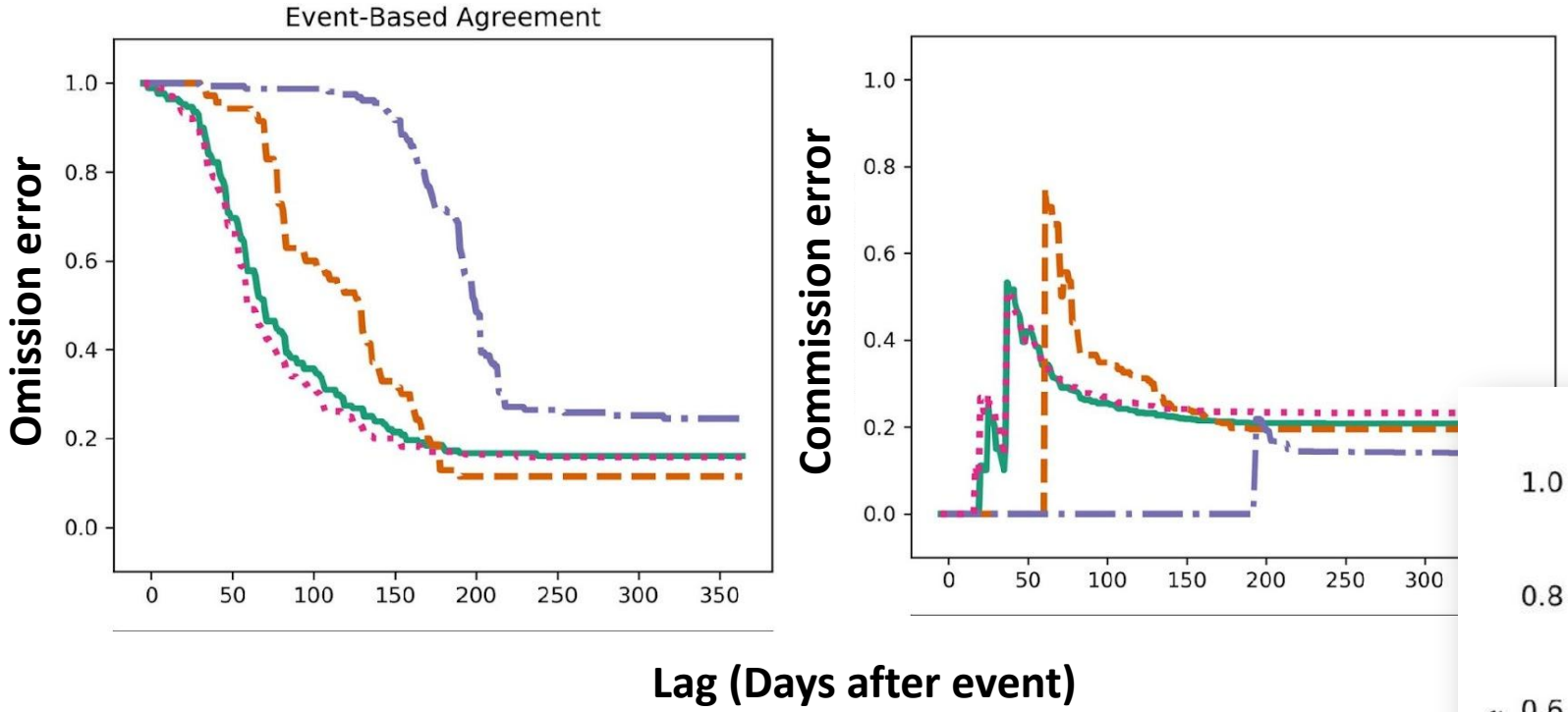
Planet Mosaic 12/2020

Planet Mosaic 11/2021

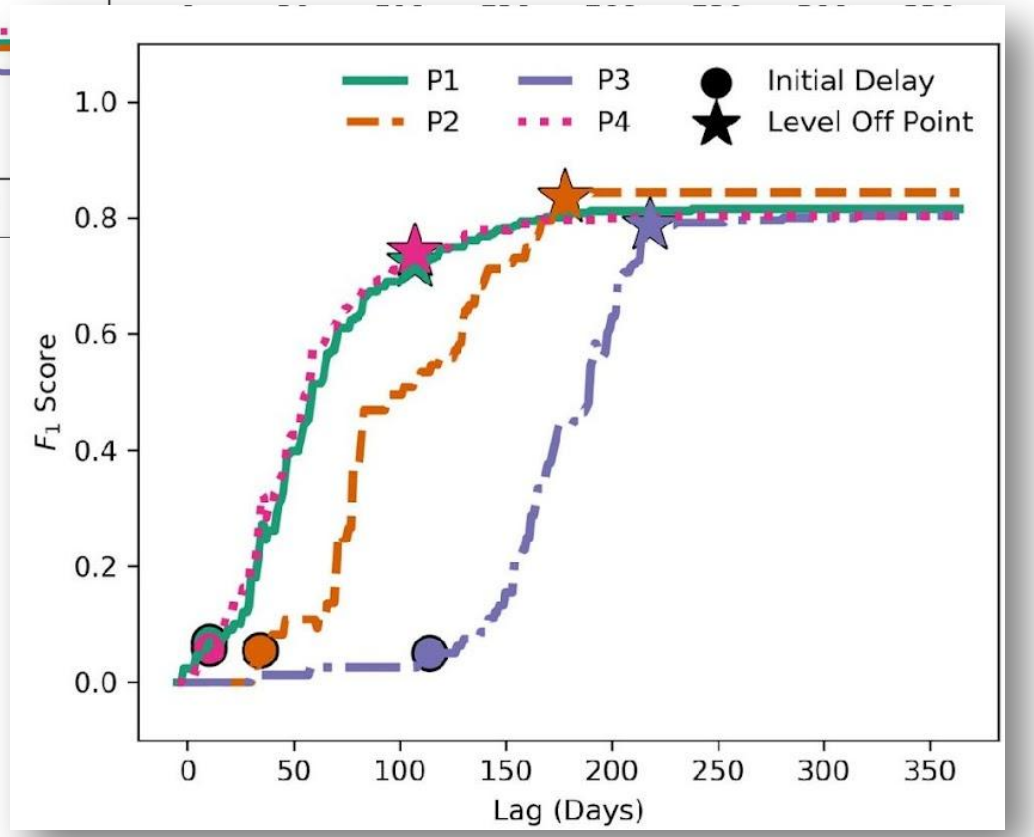



Planet NICFI
March 2022
Sentinel-1 DI (VH)
April 4, 2022
PALSAR-2 DI (HV)
March 30, 2022
-5
Disturbance Index
5
Map data ©2023
1 km
Terms of Use

Including timeliness in accuracy assessment



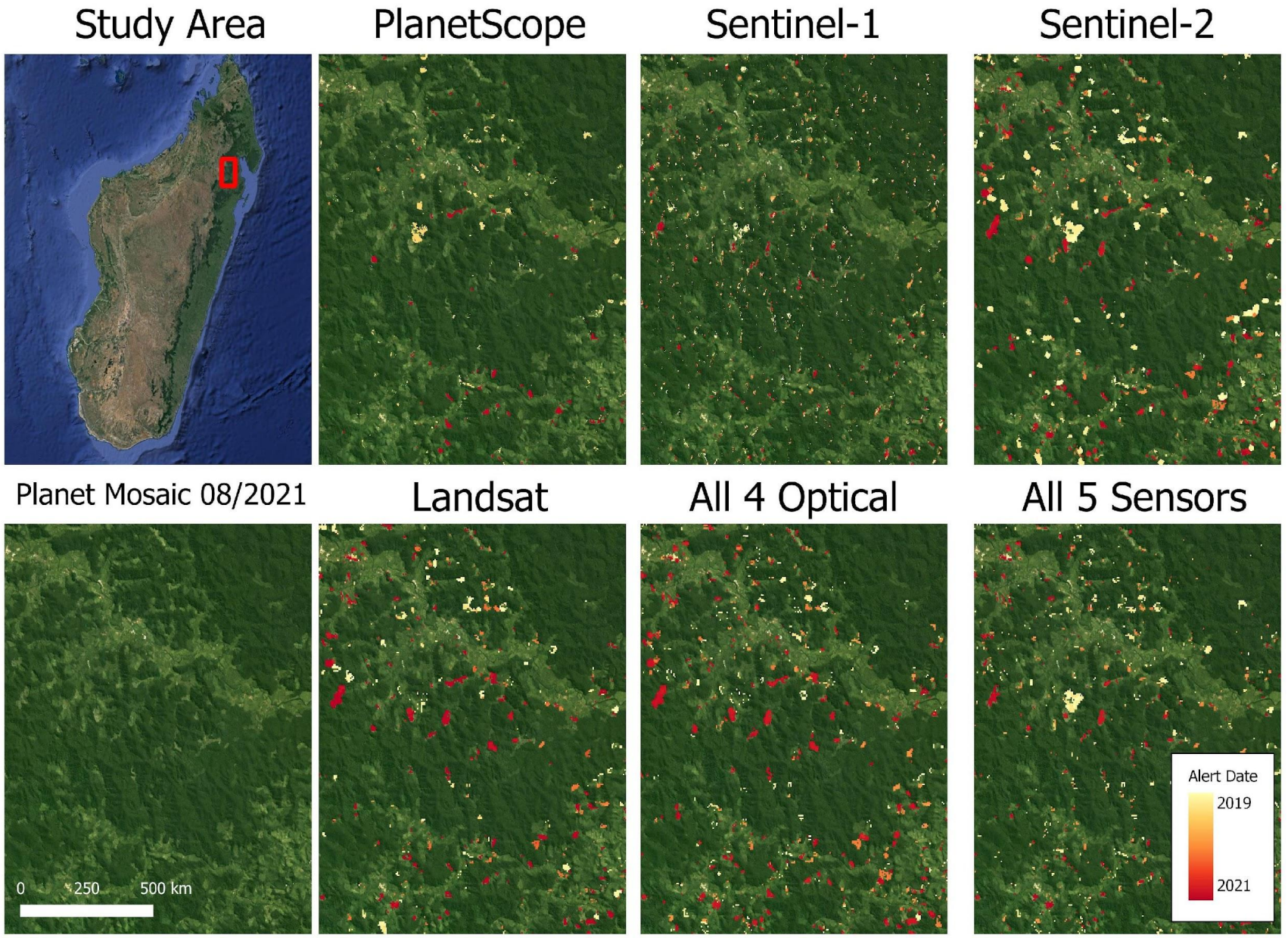
Sigmoid Accuracy

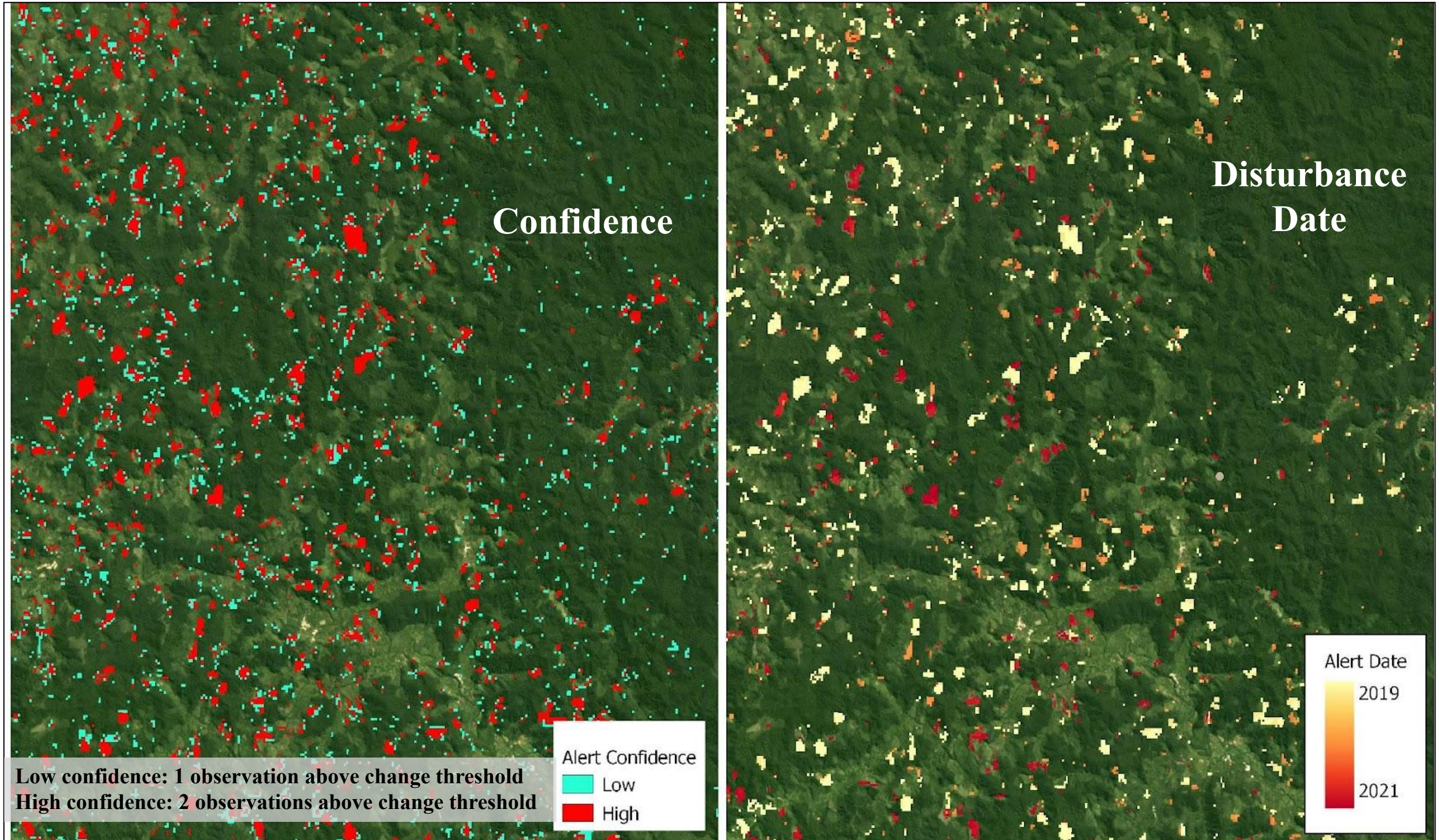


Bullock et al. (2022) RSE **276**:113043.

Case Study

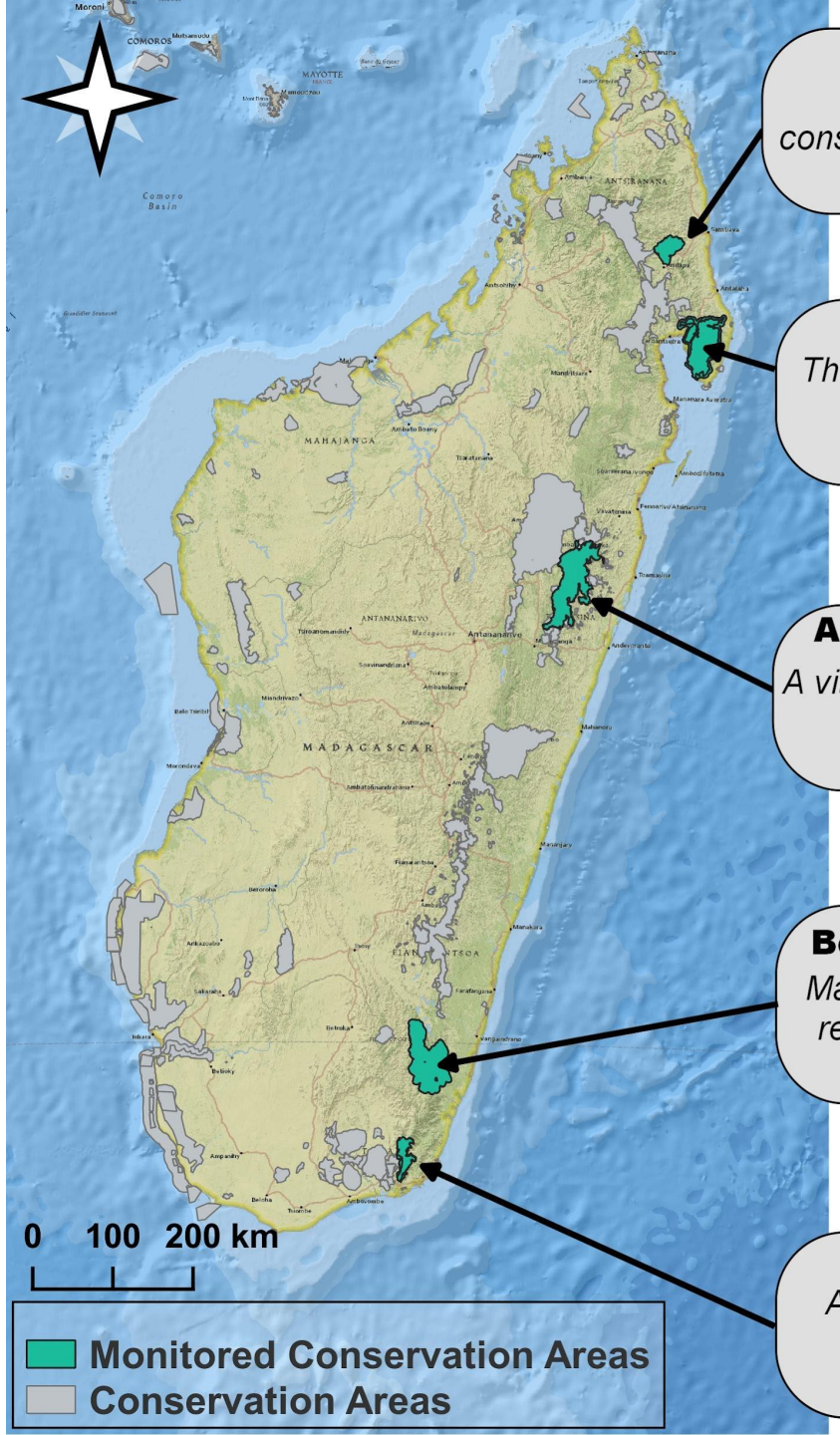
- 2019-2020
- 6 configurations of input data
- Humid tropical forests
- Stratified random sample (n=960) with precise change date attribution




Confidence
Disturbance Date
Alert Confidence
Low
High
Alert Date
2019
2021
Low confidence: 1 observation above change threshold
High confidence: 2 observations above change threshold

We’re setting up five 2-year demonstration window in protected areas of varying cloudiness

Using Planet quota donated by FAO



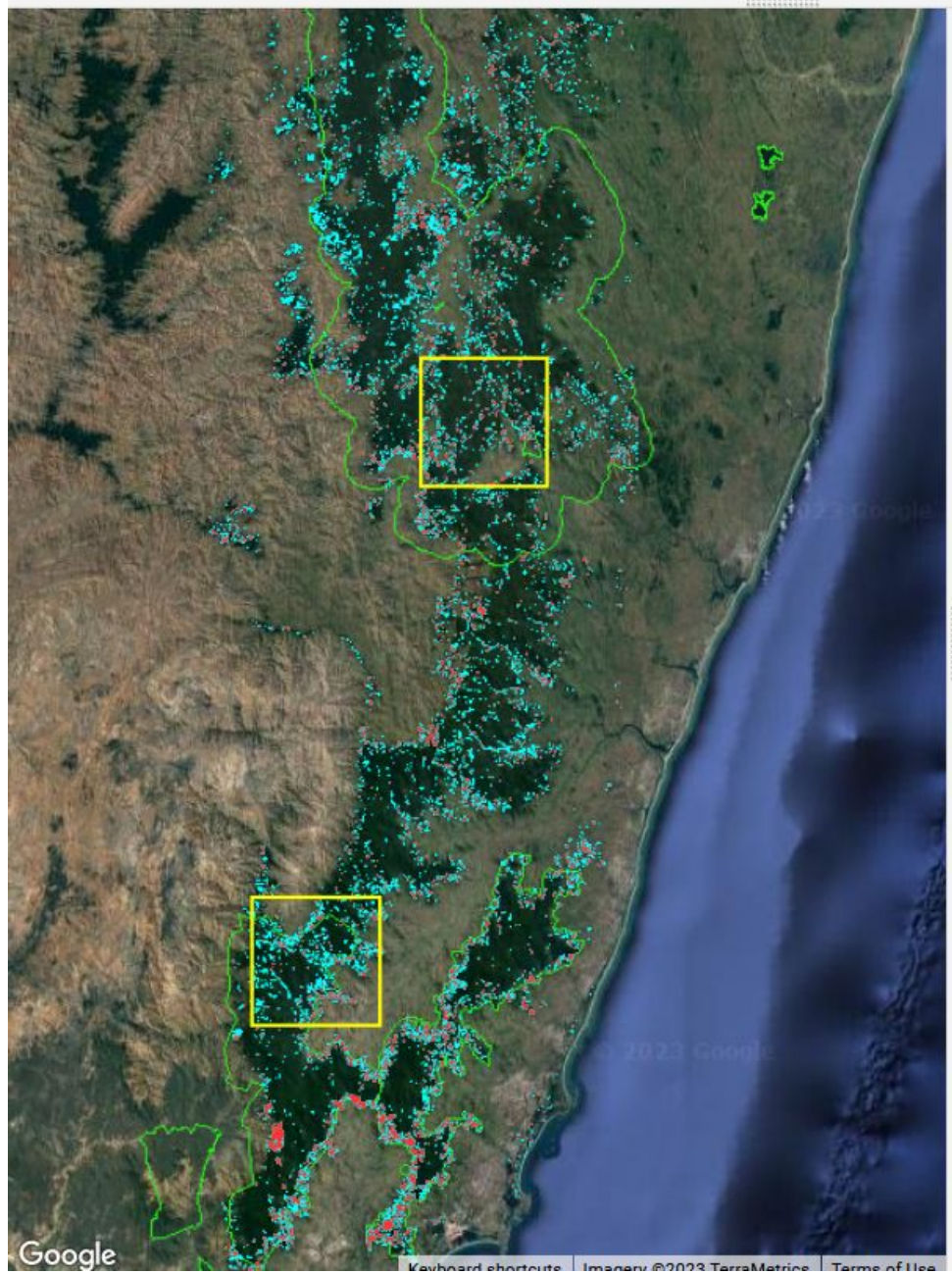
Marojejy National Park
One of the world's most distinctive conservation areas due to its diverse range of elevations and ecosystems

Masoala National Park
The largest protect area in Madagascar and is known for its exceptional biodiversity.

Ankeniheny Zahamena Corridor
A vital lifeline connecting fragmented forests of critical ecological importance.

Befotaka Midongy National Park
Madagascar's second largest rainforest is renown for its endemic plant and animal species

Andohahela National Park
A lemur's paradise with both rainforest, montane forest, and spiny desert ecosystems.



Forest Disturbance Alerts (Beta)

Map Data: Daily Forest Disturbance Alerts

Algorithm: Disturbance Index Alert System (DIAS)

Inputs: Landsat, Sentinel-2, Planet, and Sentinel-1

Updated: April 11, 2023

Alert Confidence

- High
- Low

Ancillary Layers

- Protected Areas
- Study Areas

Filter by Alert Date:

Start: Oct 1, 2022 (10 / 01 / 2022)

End: Apr 10, 2023 (04 / 10 / 2023)

Disturbance Detection Dates

Click on the map

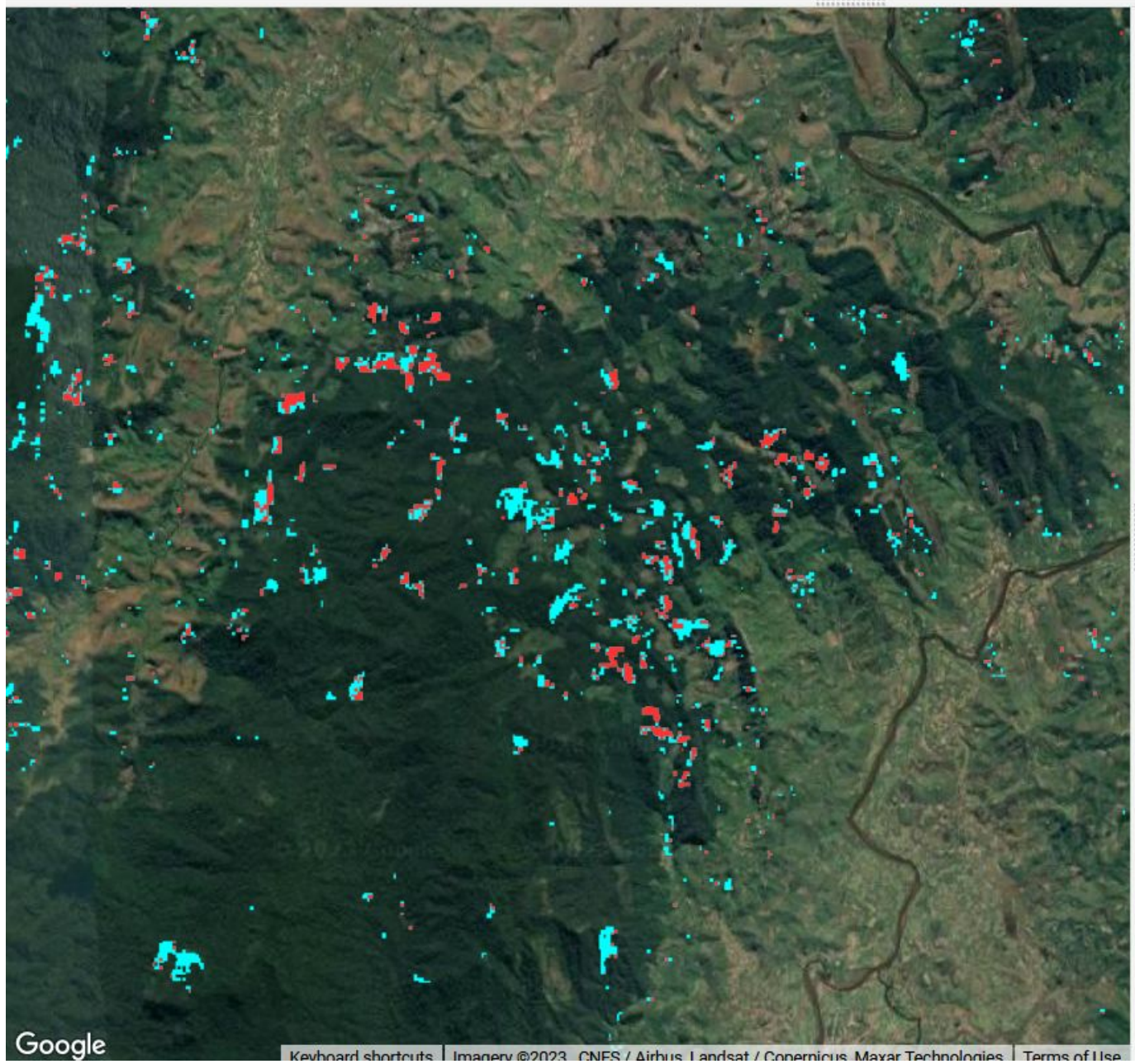
Low Confidence: 2022-3-1

High Confidence: 2022-3-7

Google Earth Engine

Search places and datasets...

nasa-andes



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Updated: April 11, 2023

Alert Confidence

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Low

Filter by Alert Date:

Start:

9 30 Oct 2 3 4 5 6

Oct 1, 2022

10 / 01 / 2022

End:

3 4 5 6 7 8 9 10

Apr 10, 2023

04 / 10 / 2023

Disturbance Detection Dates

Click on the map

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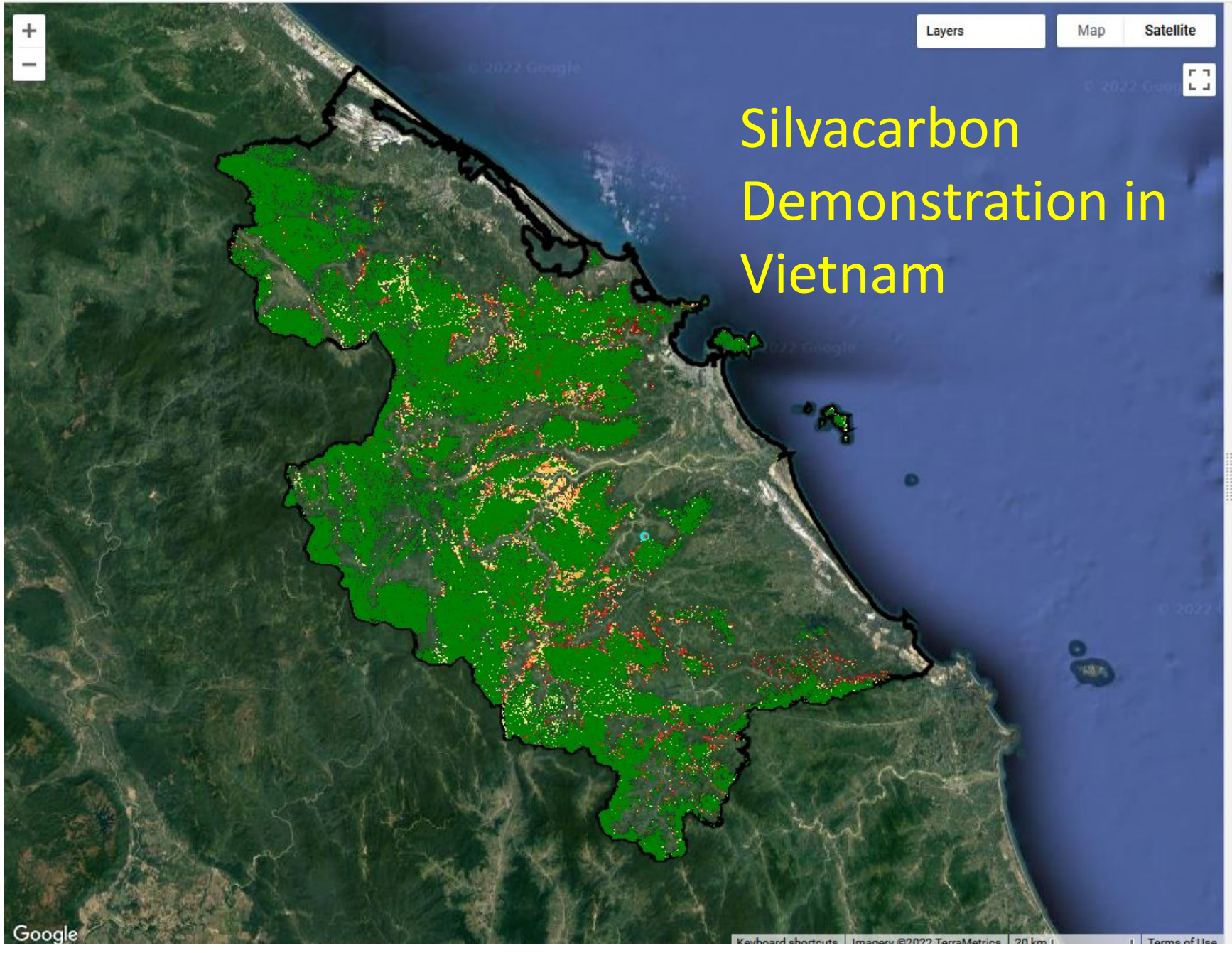
Disturbance Index Alerts

Search places

Earth Engine Apps



Disturbance Index Alerts (Beta)

Forest disturbance alerts identified in a combined time series of Sentinel-1, Sentinel-2, and Landsat images.

Legend

- Study Area
- Field Site

Alert Date

2021 — 2023

Display Options

Background Imagery: Forest Mask

Alert Format: Alert Date

Sensors: Landsat Sentinel-2 Sentinel-1

Start: Jan 1, 2021 — 01 / 01 / 2021

End: Dec 1, 2022 — 12 / 01 / 2022

Dates of Detection and Alerts:

First Identified: 2022-4-25

Confirmed Alert: 2022-4-27

Disturbance Index Alerts (Beta)

Forest disturbance alerts identified with a combined time series of Sentinel-1, Sentinel-2, and Landsat images.

Legend

Study Area

Alert Date

2022 — 2023

Display Options

Background Imagery: Google Satellite

Alert Format: Alert Date

Input Sensors: Default

Start: End:

Oct 2 3 4 5 6 7 9 30 Dec 2 3 4 5 6

Oct 1, 2021 — Dec 1, 2022

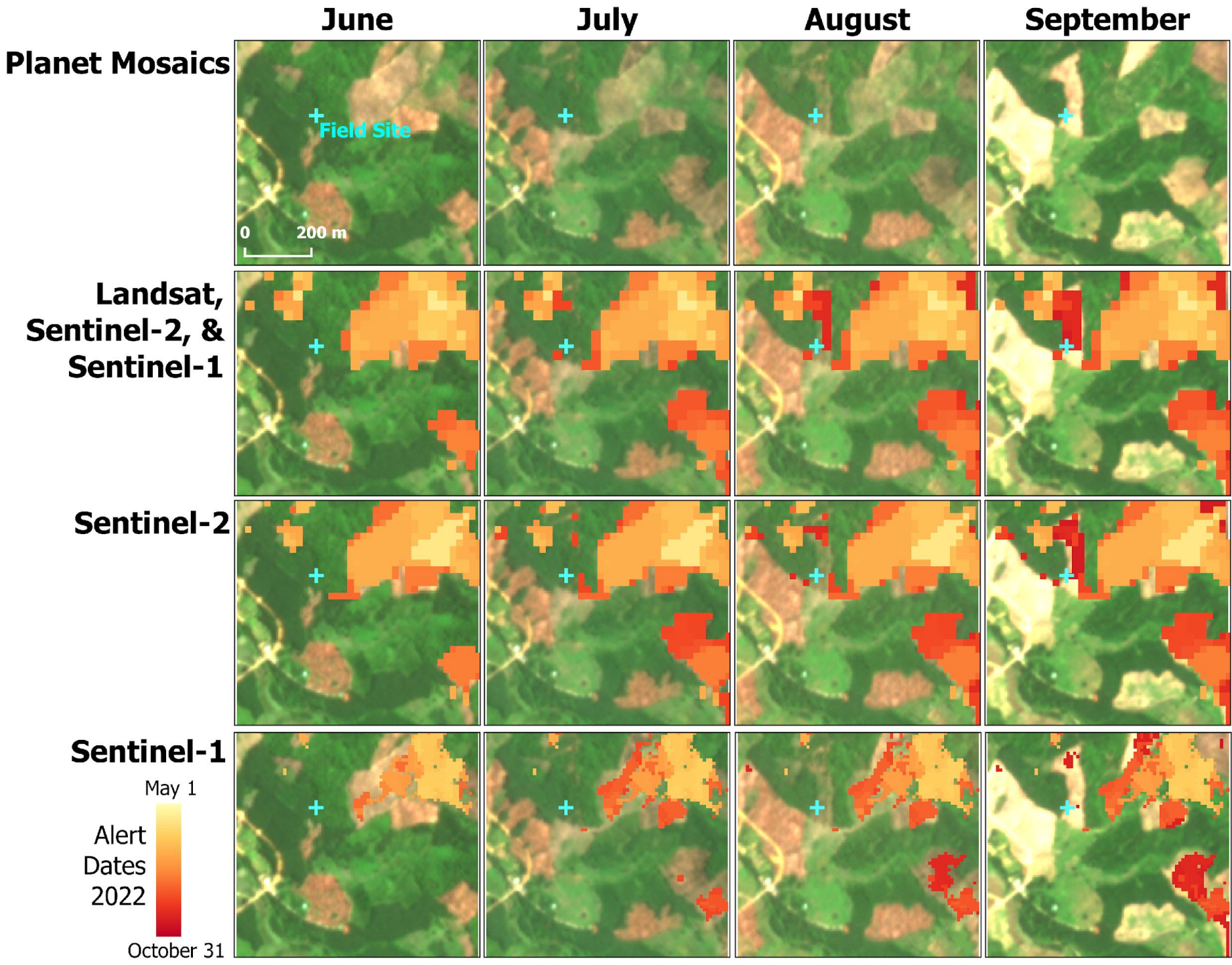
10 / 01 / 2021 — 12 / 01 / 2022

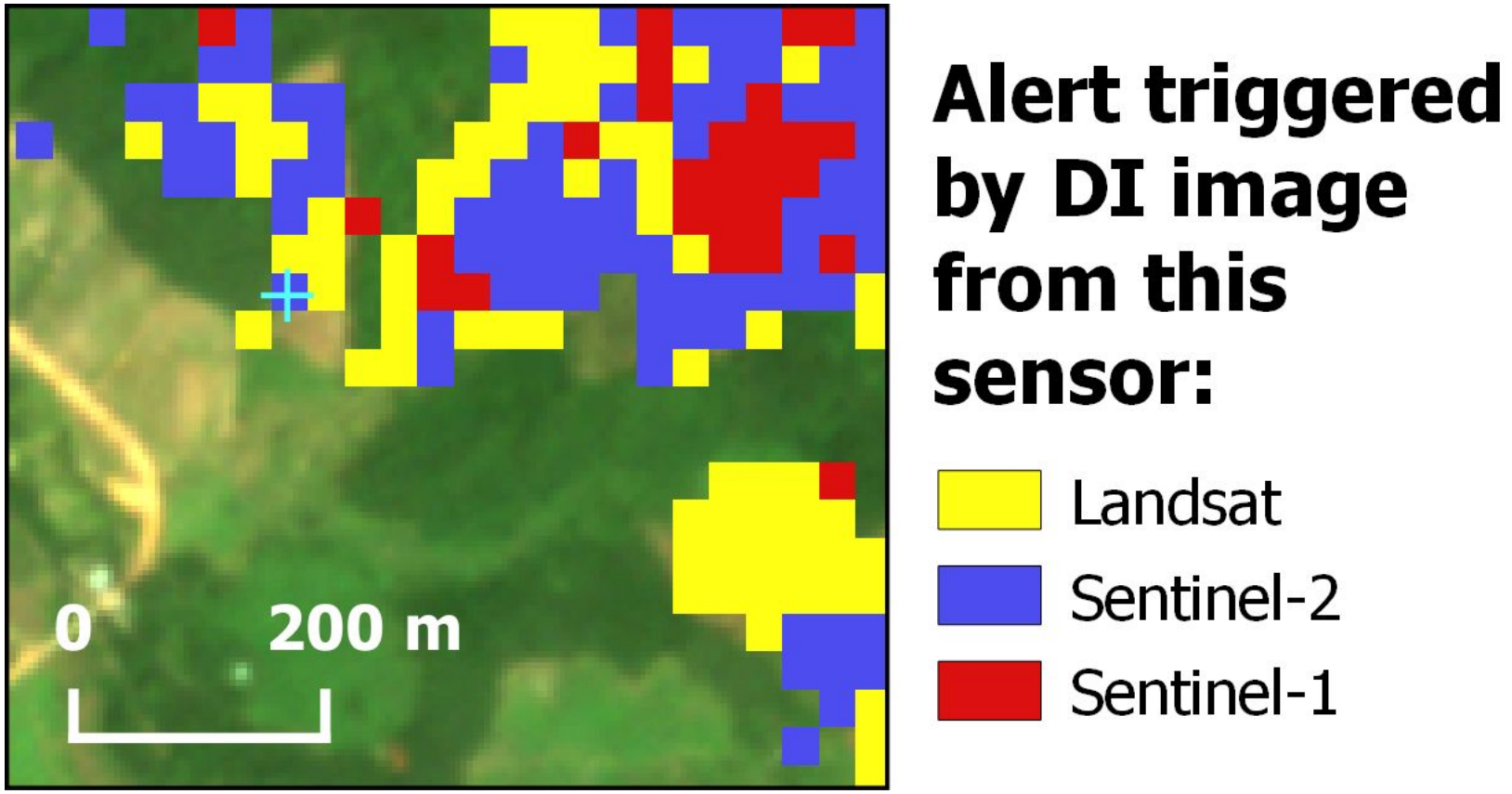
Dates of Detection and Alerts:

First Identified: 2022-3-23

Confirmed Alert: 2022-3-29

Vietnam Field Site





Even in this small area, all 3 sensors were important in detecting change as soon as possible