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Classifying direct drivers of forest disturbance in near real-time, using multi-sensor Sentinel data and deep learning

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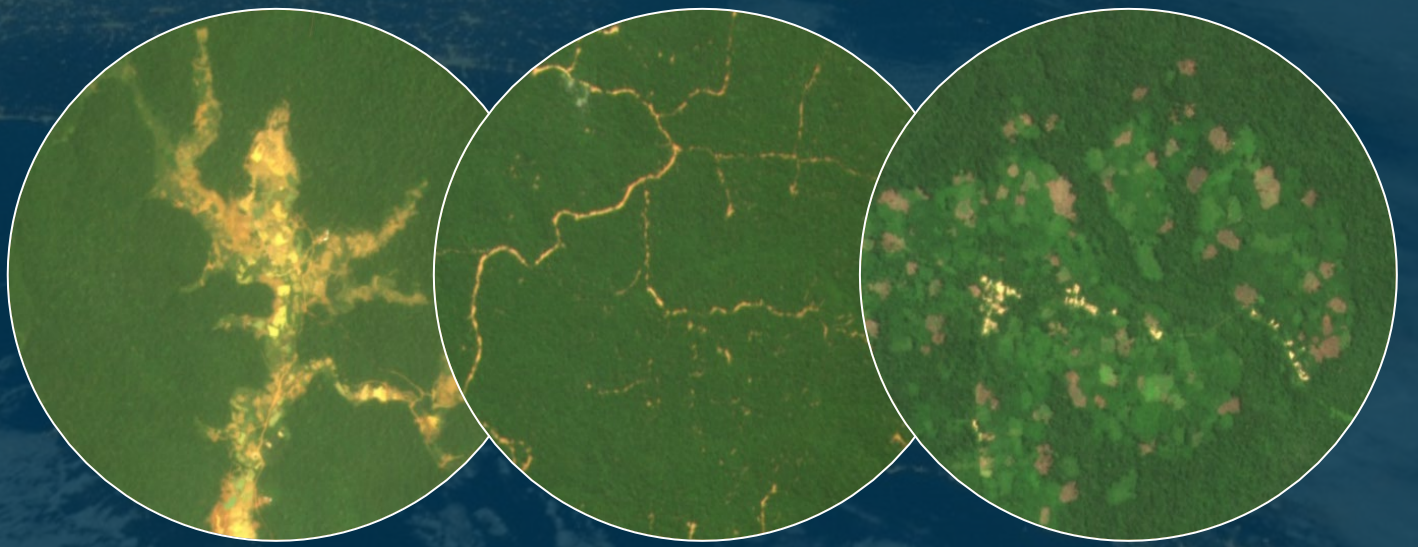

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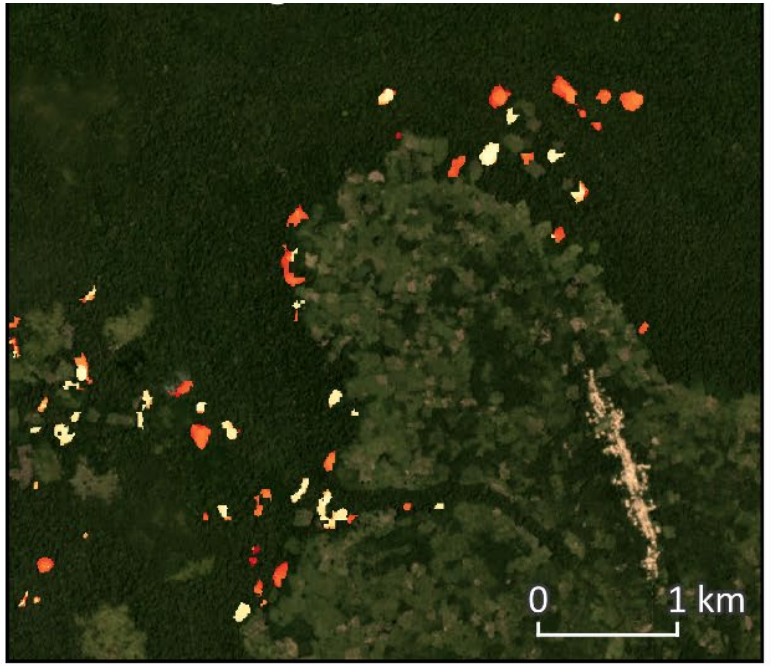
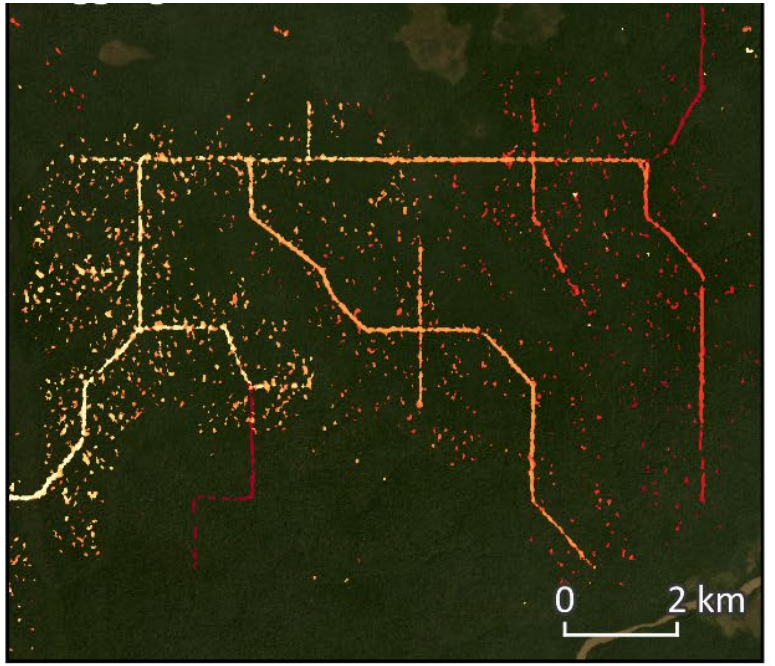
Background – Near real-time disturbance alerts (RADD)

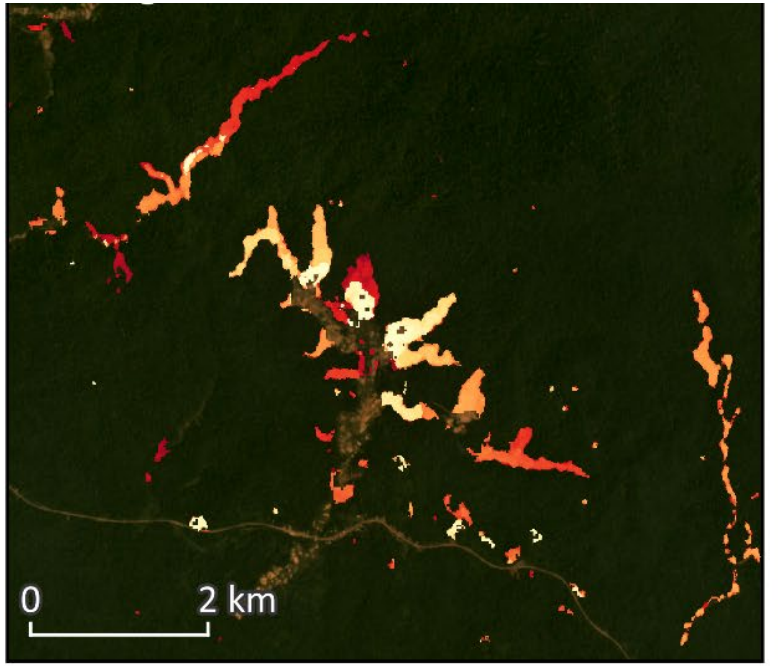
Smallholder agriculture



Roads + selective logging



Mining

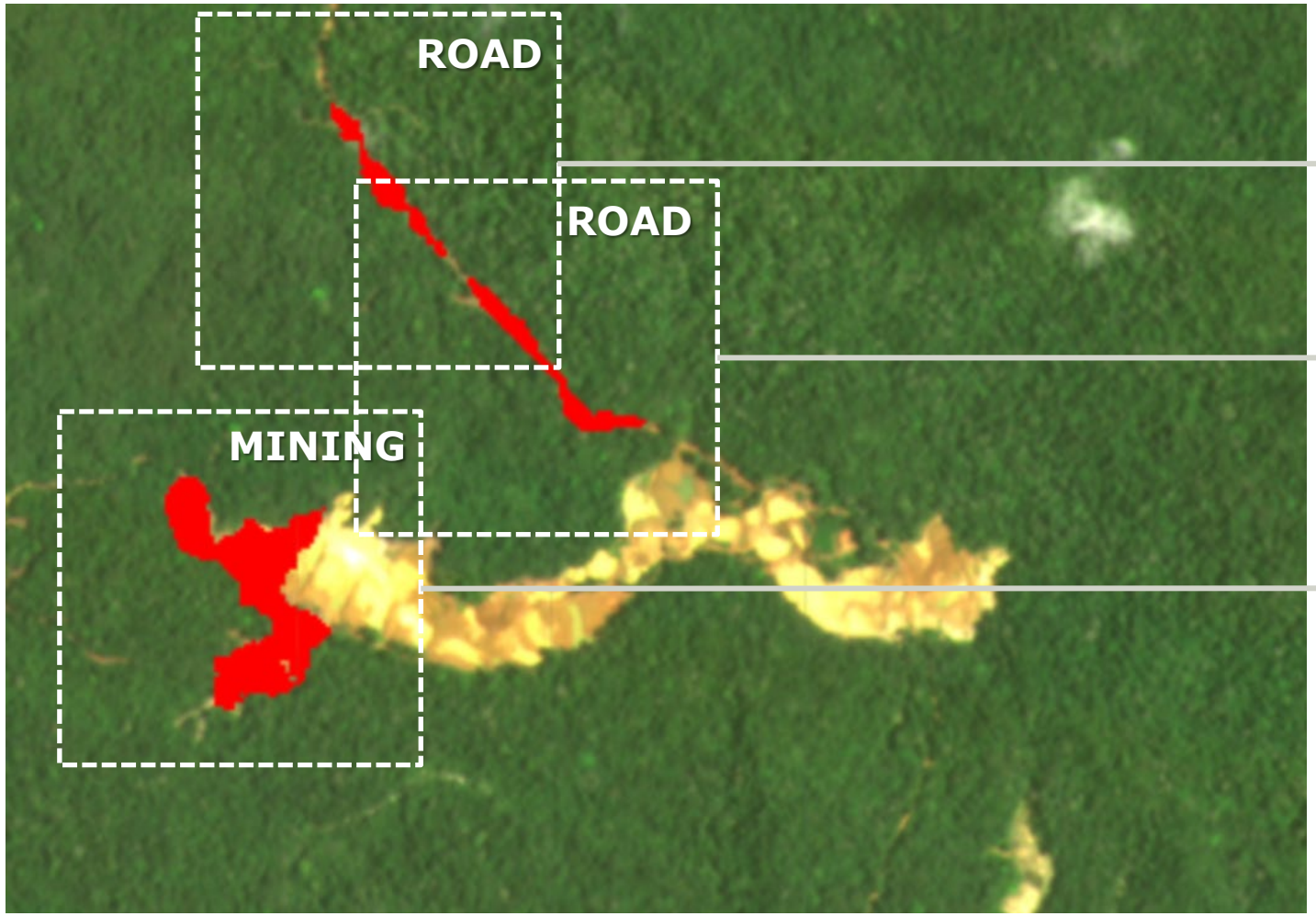


RADD alerts (Reiche et al. 2021 *Env. Res. Lett.*)

Concept – Classifying direct disturbance drivers

- At the level of a detected forest disturbance patch (spatially explicit)
- As timely as possible (near real-time)
- Using Sentinel-1-based RADD alerts, Sentinel-1 and Sentinel-2 data, and a convolutional neural network
- Mapping 4 classes:
  - Road development
  - Selective logging
  - Mining
  - Smallholder agriculture

Concept – Convolutional neural network



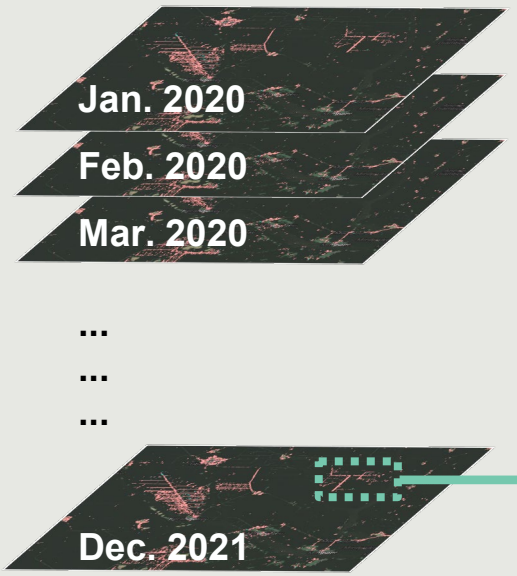
Add S1 & S2 data → CNN

Add S1 & S2 data → CNN

Add S1 & S2 data → CNN

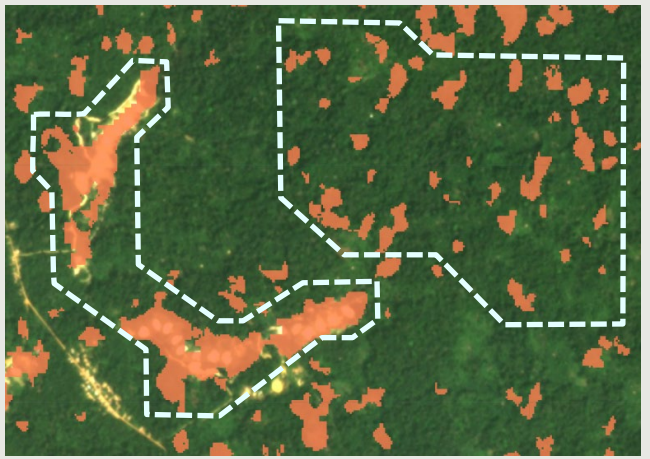
Methods – Training sample acquisition

Disturbance alerts



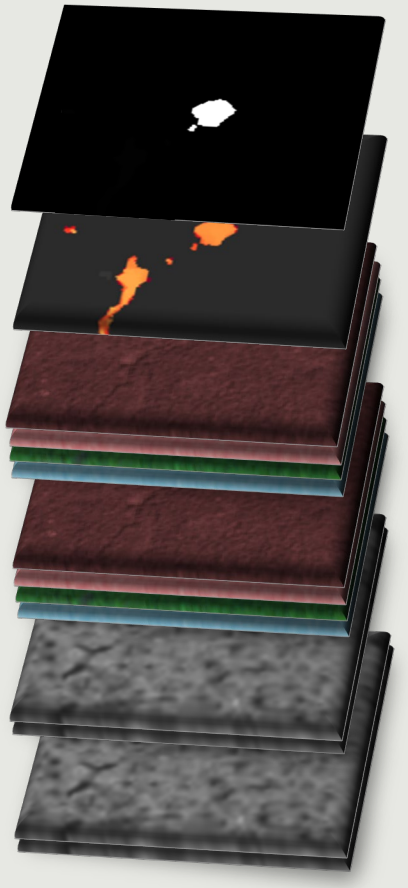
Created disturbance layers
- Disturbances mapped for 2 years
- 24 alert layers (monthly)

Reference polygons



Class polygons
- Road development
- Selective logging
- Mining
- Smallholder agriculture
- Other

Input Images (~80.000)



Forest disturbance patch
Binary layer (RADD)

Surrounding disturbance
Disturbance dates scaled (RADD)

Sentinel-2 composite before
SWIR, NIR, Red, Green
Cloudshadow-masked *median* composite

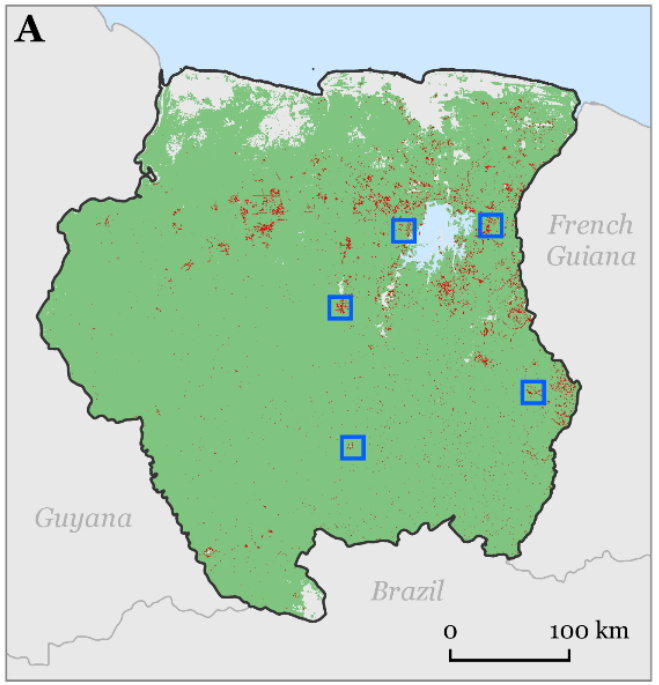
Sentinel-2 composite after
SWIR, NIR, Red, Green
Cloudshadow-masked *quality* composite

Sentinel-1 composite before
VV, VH, Descending, terrain-corrected
Median composite

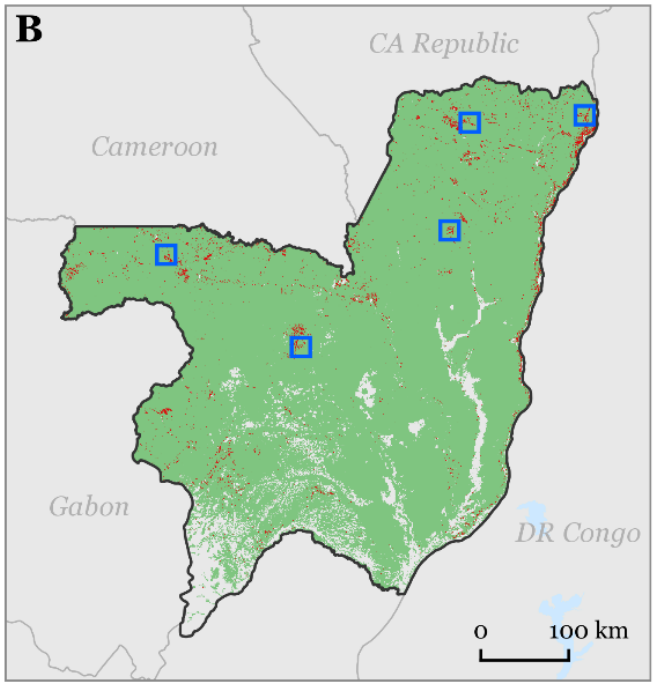
Sentinel-1 composite after
VV, VH, Descending, terrain-corrected
Median composite

Methods – Study areas

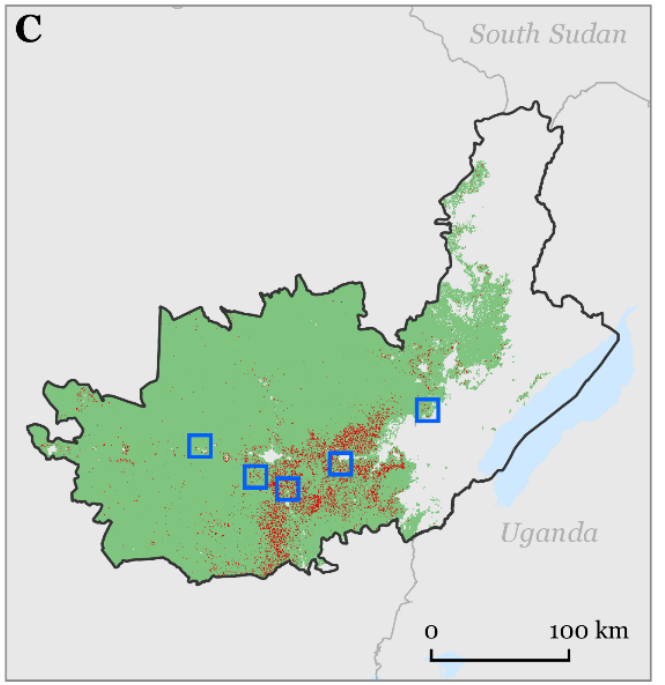
Suriname
Whole country



Republic of the Congo
Likouala, Sangha, Cuvette, Cuvette-Ouest



Democratic Republic of the Congo
Ituri



Testing areas

Primary humid tropical forest

RADD forest disturbance alert (2020 & 2021)

Results – Image classification

6 months

2 months

Sm. agriculture (0.77)

Mining (0.96)

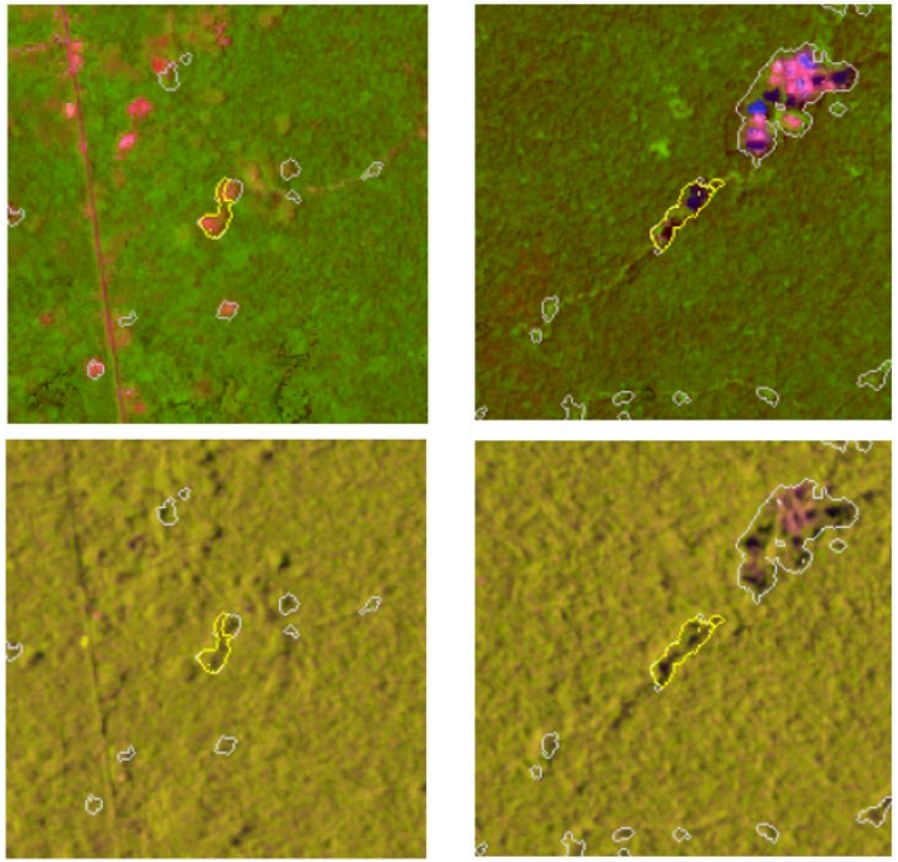
Sel. logging (0.97)

Road dev. (0.86)

Sel. logging (0.69)

Sentinel-2

Sentinel-1



Results – Near real-time scenario

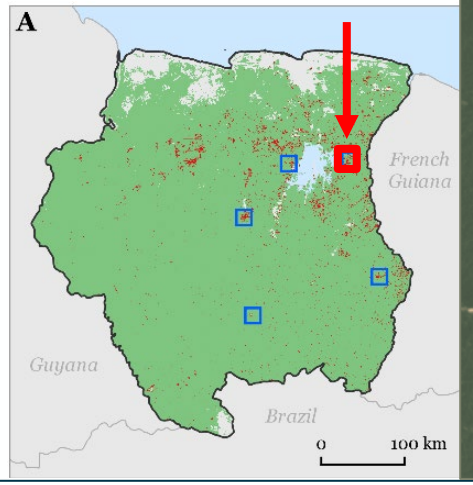
Classifying disturbance patches:
- Within 2 months
- > 0.80 confidence

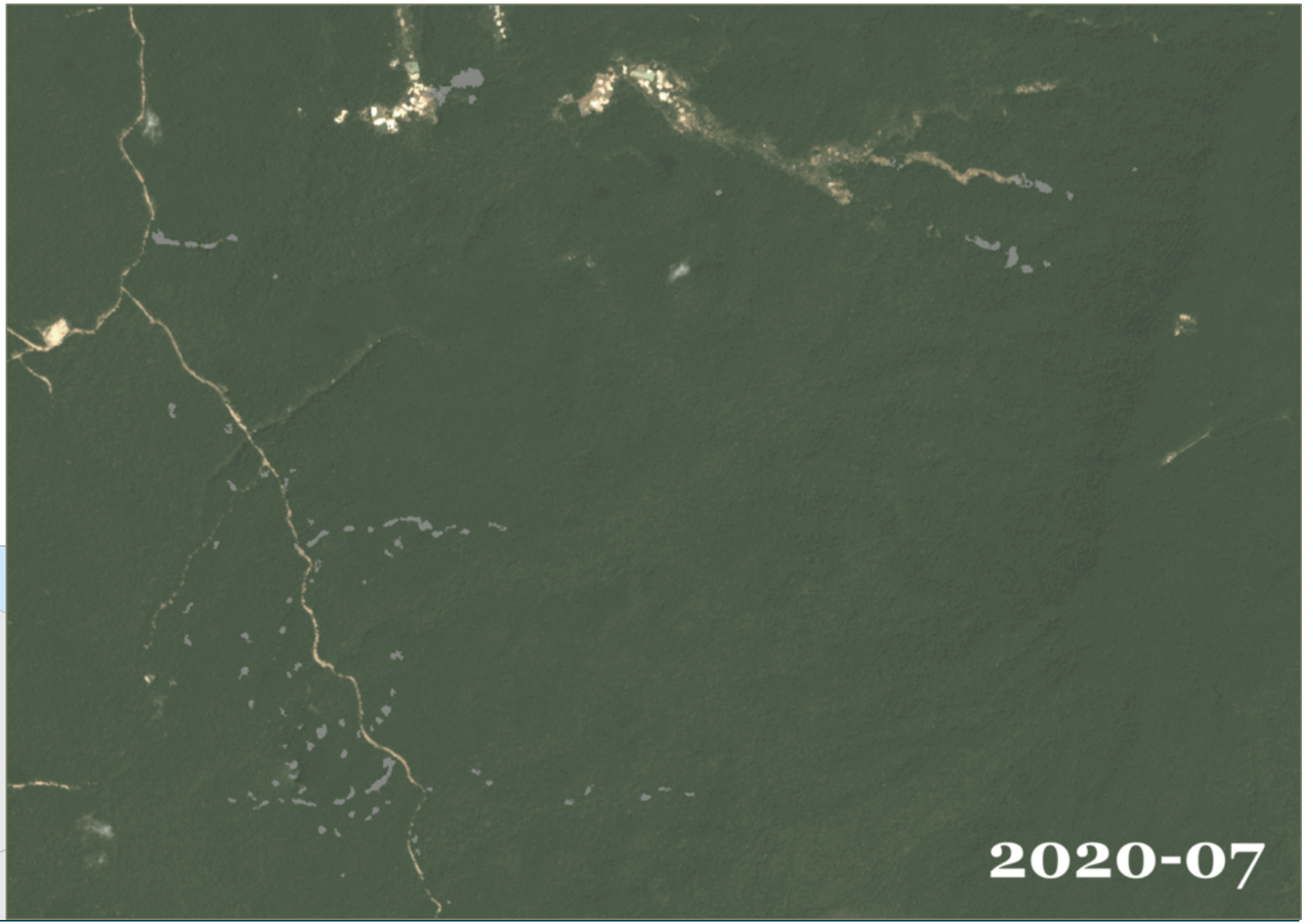
Alerts: 2021-2022

Road development

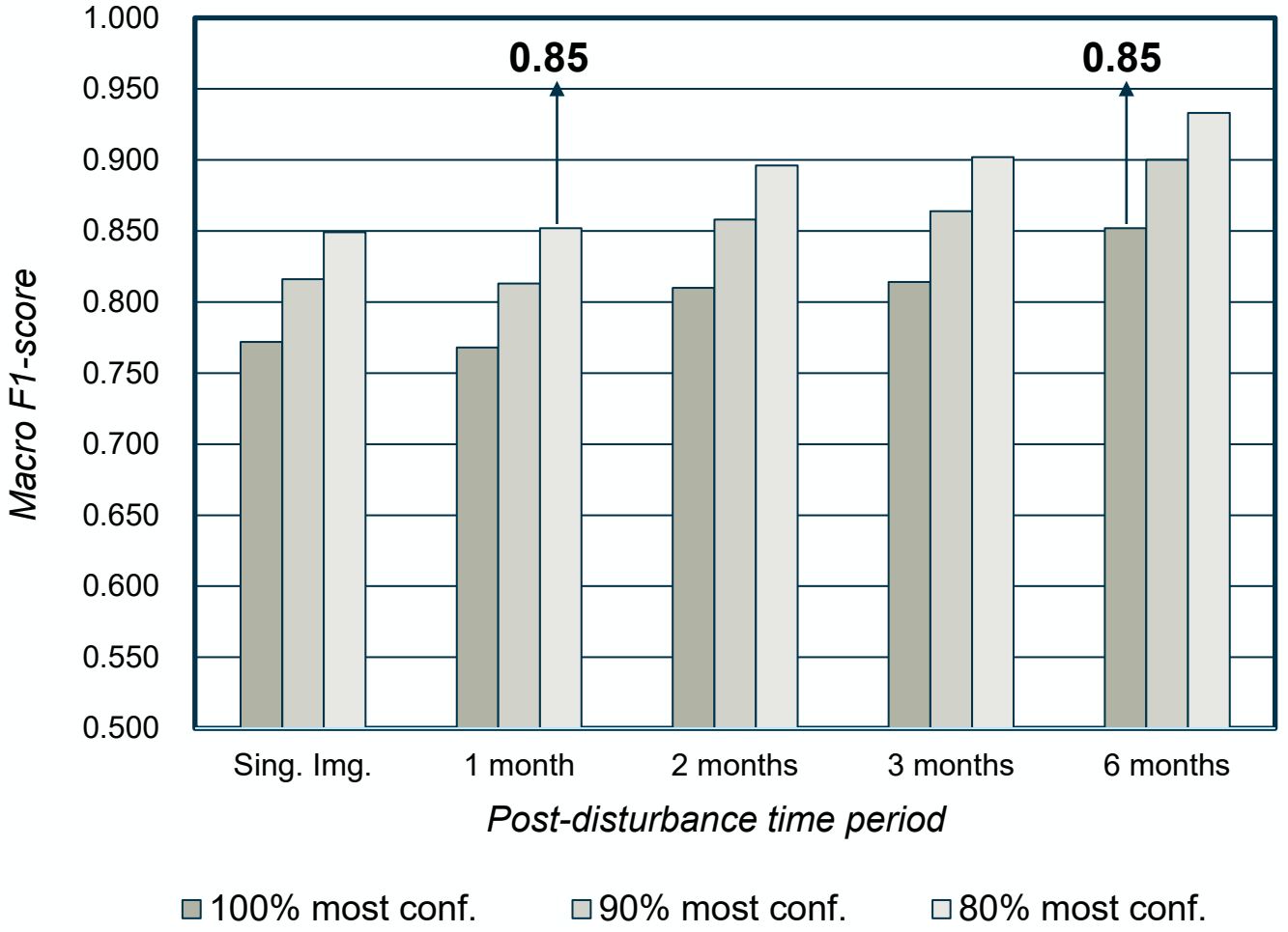
Selective logging

Mining





Results – Classification accuracies



	Precision	Recall	F1
Sm. agriculture	P: 0.976	R: 0.951	F1: 0.964
Road development	P: 0.773	R: 0.872	F1: 0.820
Selective logging	P: 0.876	R: 0.749	F1: 0.808
Mining	P: 0.771	R: 0.874	F1: 0.819

Take-aways and conclusion

- Drivers could be classified rapidly with accuracies up to 0.85 for different user scenarios.
- Driver classifications are most accurate when a longer post-disturbance time period or a confidence threshold is used.
- Potential end users could weigh classification rapidness, confidence and accuracy suiting their needs.

Thank you

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