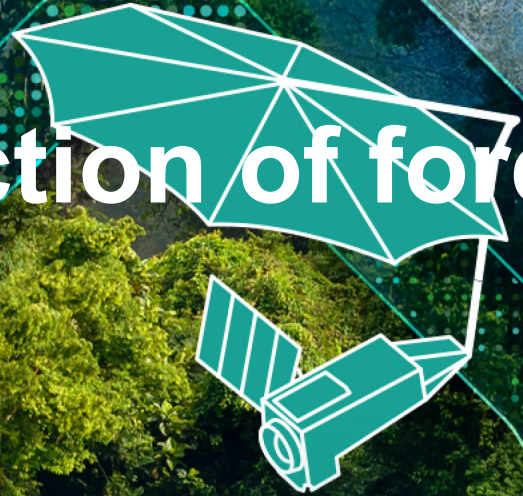


Improving early detection of forest disturbances in the tropics



S. Mermoz¹, T. Koleck^{2,3}, J. Doblas¹, A. Bouvet³, M. Bottani^{2,4},
L. Ferro-Famil^{3,4}, T. Le Toan³

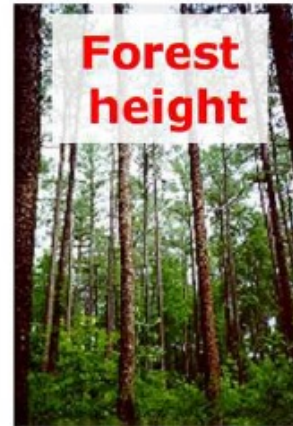
¹GlobEO ²CNES ³CESBIO ⁴ISAE Supaero



The BIOMASS mission objectives



**Above-ground biomass
(tons / hectare)**



**Upper canopy height
(meter)**



**Areas of forest clearing
(hectare)**

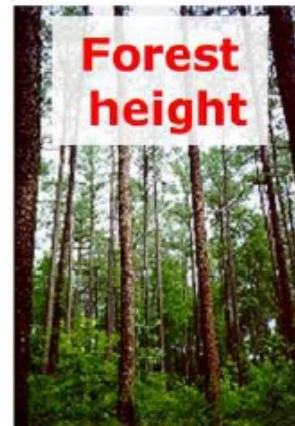
- 50 m pixel size
- 6 months temporal resolution
- 90% accuracy

The BIOMASS mission objectives

Spatial and temporal resolutions can be enhanced using multi-mission data



**Above-ground biomass
(tons / hectare)**



**Upper canopy height
(meter)**

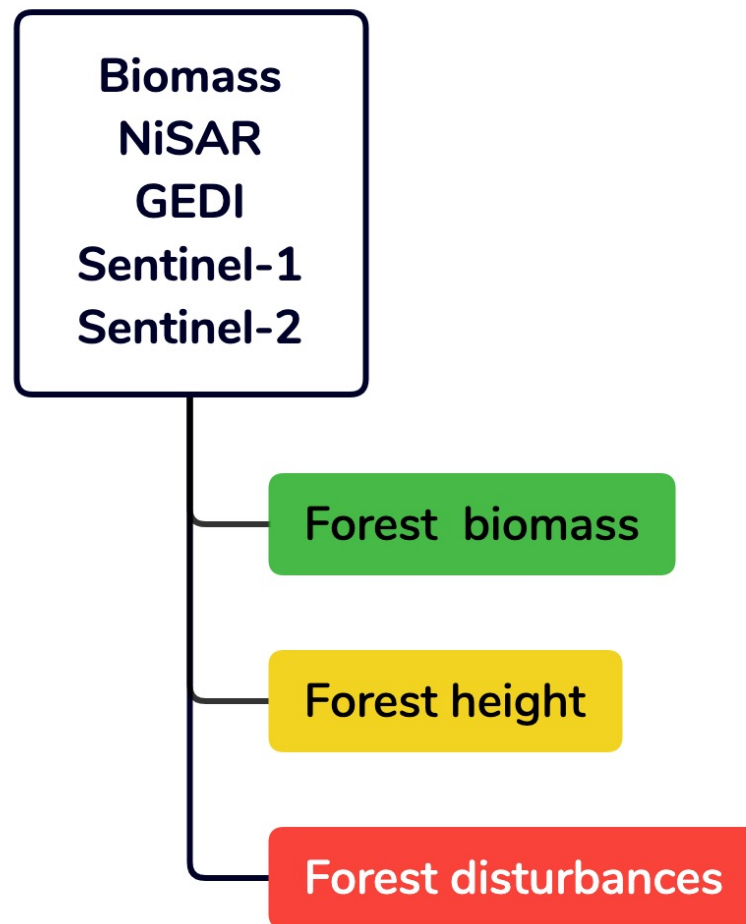


**Areas of forest clearing
(hectare)**

- 50 m pixel size
- 6 months temporal resolution
- 90% accuracy

The BIOMASS mission objectives

Spatial and temporal resolutions can be enhanced using multi-mission data



Operational forest loss alert system



- Based on SAR Sentinel-1 data
- Every 6 to 12 days
- Minimum mapping unit of 0.1 hectare (pixel size 10m)





- Based on SAR Sentinel-1 data
- Every 6 to 12 days
- Minimum mapping unit of 0.1 hectare (pixel size 10m)

To

- Detect and identify illegal activities, management of protected areas, monitor the conservation agreement, enforce the certification labels
- Contribute to the European strategy against imported deforestation to improve the sustainability of goods

How did we get there



Students



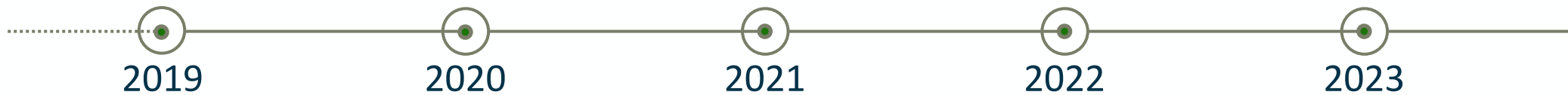
Projects



SOFT
Forest loss in Southeast Asia



TropiSCO
Forest loss in the tropics



remote sensing MDPI

Article

Use of the SAR Shadowing Effect for Deforestation Detection with Sentinel-1 Time Series

Alexandre Bouvet ^{1,*}, Stéphane Mermoz ¹, Marie Ballère ¹, Thierry Koleck ^{1,2} and Thuy Le Toan ¹

¹ CESBIO, Université de Toulouse, CNES/CNRS/IRD/UPS, 31400 Toulouse, France; stephane.mermoz@gmail.com (S.M.); marie.ballere@cesbio.cnes.fr (M.B.); thierry.koleck@cnes.fr (T.K.); thuy.letaoan@cesbio.cnes.fr (T.L.T.)
² CNES, 31400 Toulouse, France
 * Correspondence: alexandre.bouvet@gmail.com

Received: 22 June 2018; Accepted: 6 August 2018; Published: 8 August 2018

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

SAR data for tropical forest disturbance alerts in French Guiana: Benefit over optical imagery

Marie Ballère ^{a,b,c,*}, Alexandre Bouvet ^d, Stéphane Mermoz ^{d,e}, Thuy Le Toan ^d, Thierry Koleck ^a, Caroline Bedeau ^f, Mathilde André ^f, Elodie Forestier ^f, Pierre-Louis Frison ^c, Cédric Lardeux ^g

^a Centre National d'Etudes Spatiales, 31400 Toulouse, France
^b World Wildlife Fund France, 93310 Le Pré-Saint-Gervais, France
^c LASTIG, University of Gustave Eiffel, IGN, 77420 Champs-sur-Marne, France
^d CESBIO, Université de Toulouse, CNES/CNRS/IRD/UPS, 31400 Toulouse, France
^e GlobEO, 31400 Toulouse, France
^f Office National des Forêts Guyane, 97300 Cayenne, France
^g ONF International, Paris, France

remote sensing MDPI

Article

Continuous Detection of Forest Loss in Vietnam, Laos, and Cambodia Using Sentinel-1 Data

Stéphane Mermoz ^{1,*}, Alexandre Bouvet ^{1,2}, Thierry Koleck ³, Marie Ballère ^{3,4,5,6} and Thuy Le Toan ²

¹ GlobEO, 31400 Toulouse, France; alexandre.bouvet@cesbio.cnes.fr
² CNRS/CNES/IRD/INRAE/UPS, CESBIO, Université de Toulouse, 31400 Toulouse, France; thuy.letaoan@cesbio.cnes.fr
³ Centre National d'Etudes Spatiales, 31400 Toulouse, France; thierry.koleck@cnes.fr (T.K.); marie.ballere@cerema.fr (M.B.)
⁴ World Wildlife Fund France, 93310 Le Pré-Saint-Gervais, France
⁵ LASTIG, IGN, University of Gustave Eiffel, 77420 Champs-sur-Marne, France
⁶ Cerema Sud-Ouest, 31400 Toulouse, France
 * Correspondence: mermoz@globoe.net

Operational forest loss alert SAR-based systems

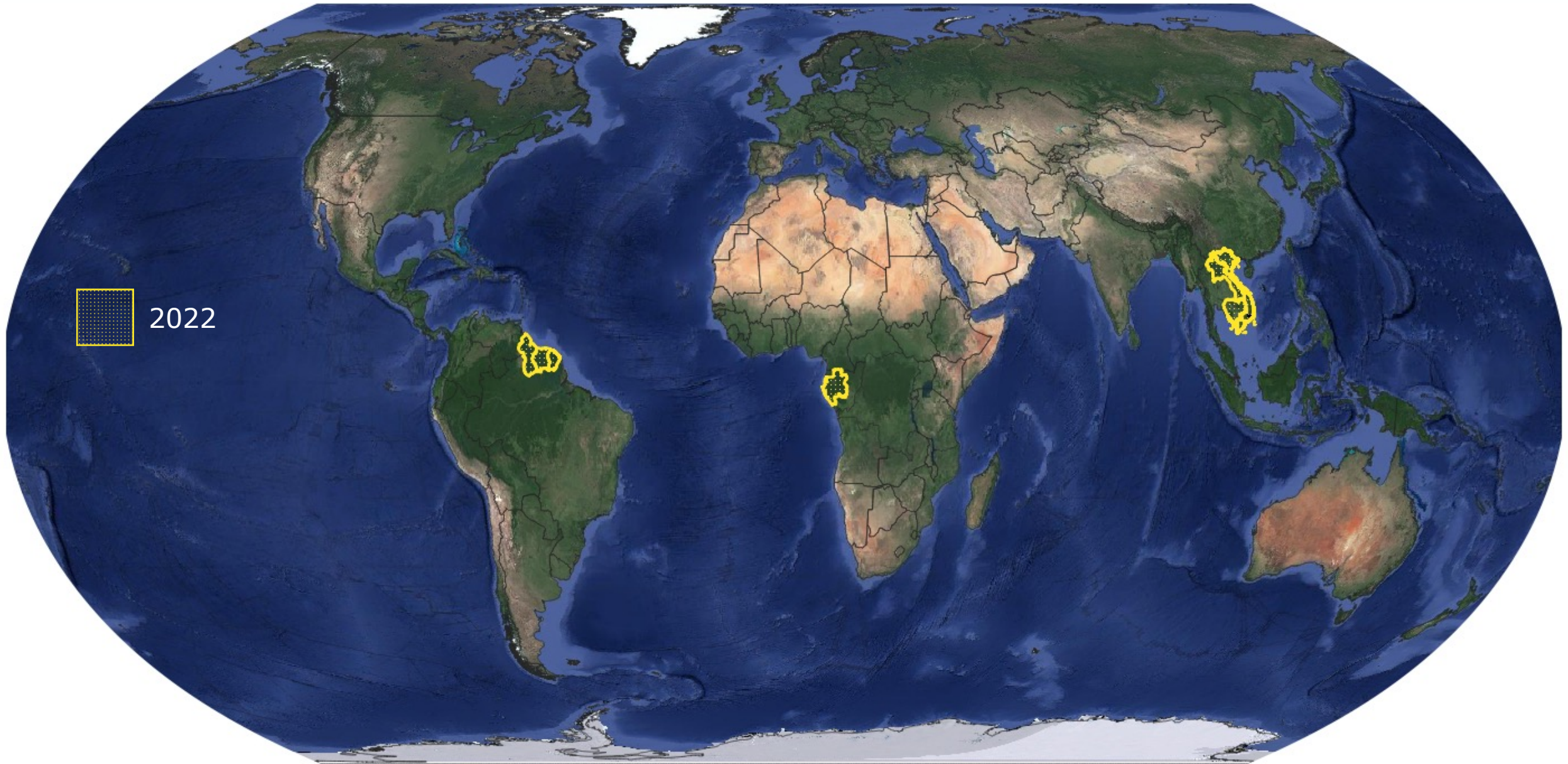


System	Input images	Temporal resolution (d)	MMU (ha)	Processing Env.	Geographical coverage	Accuracy	Particularity
TropiSCO	S1 Asc/Des	6-12	0.1	CNES HPC	7 countries	+++	Country adapted
Deter-R	S1 Des	12	0.1	GEE	Legal Amazonia (Brazil)	+++	Country adapted
RADD	S1 Asc/Des	6-12	0.1	GEE	44 countries	+++	Uniform across countries
JJ-FAST	ALOS2-PALSAR2	42	2	JAXA HPC	77 countries	+	Uniform across countries

Doblas et al.
IJRS, 2023



In 2022 we mapped 7 countries



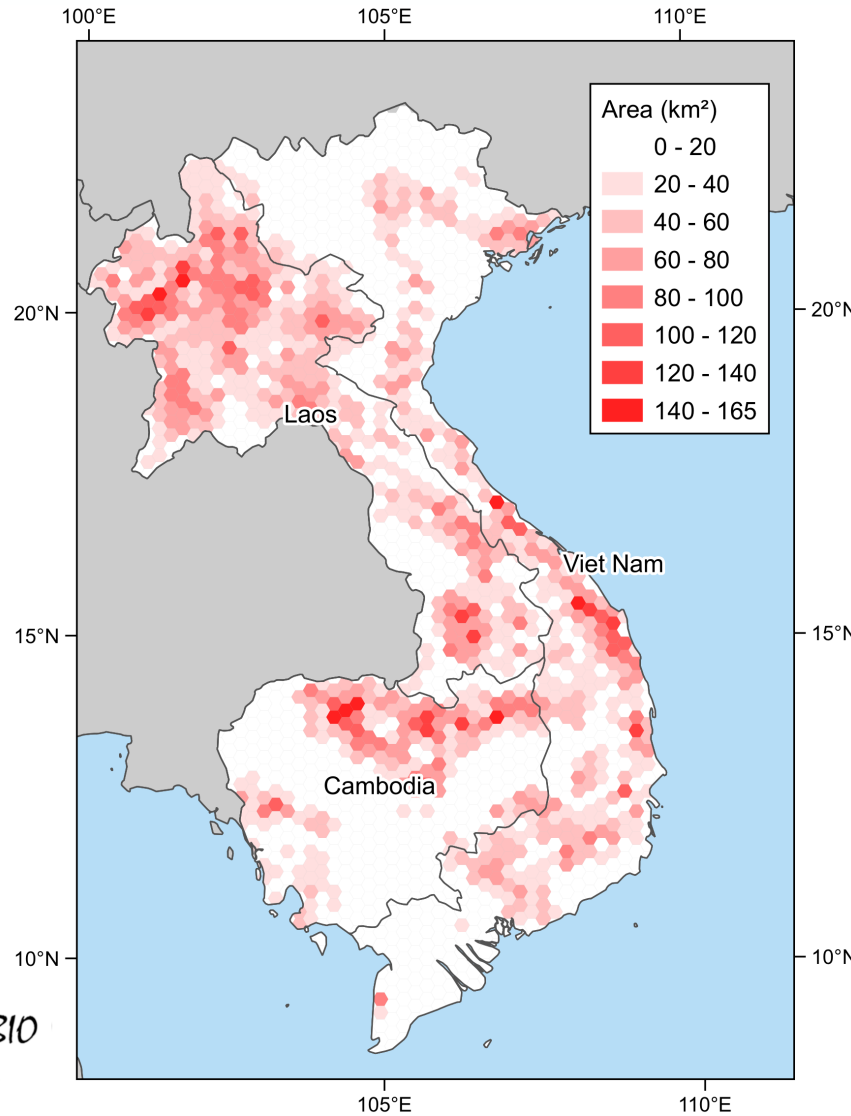
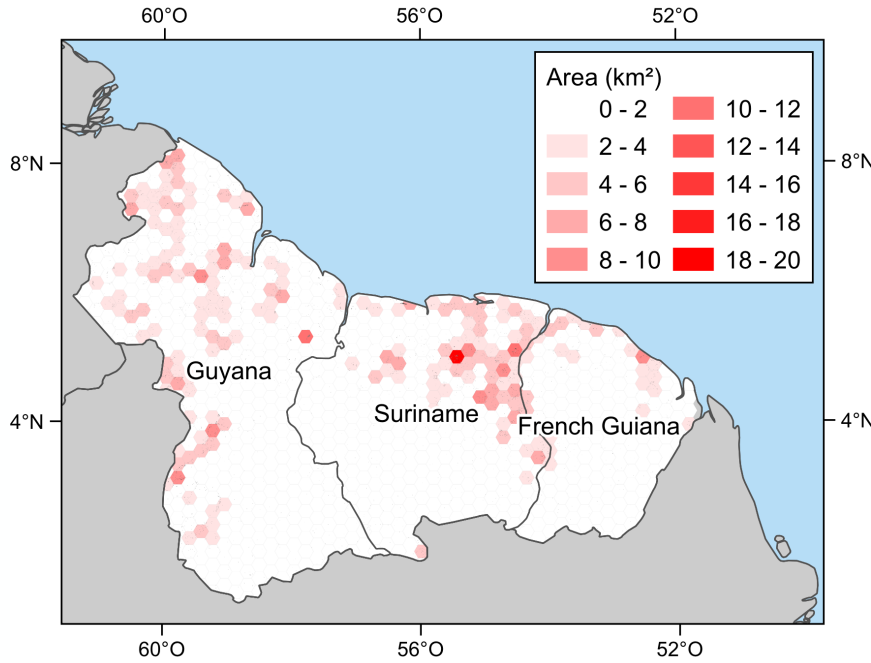
In 2022 we mapped 7 countries with which we collaborate @esa



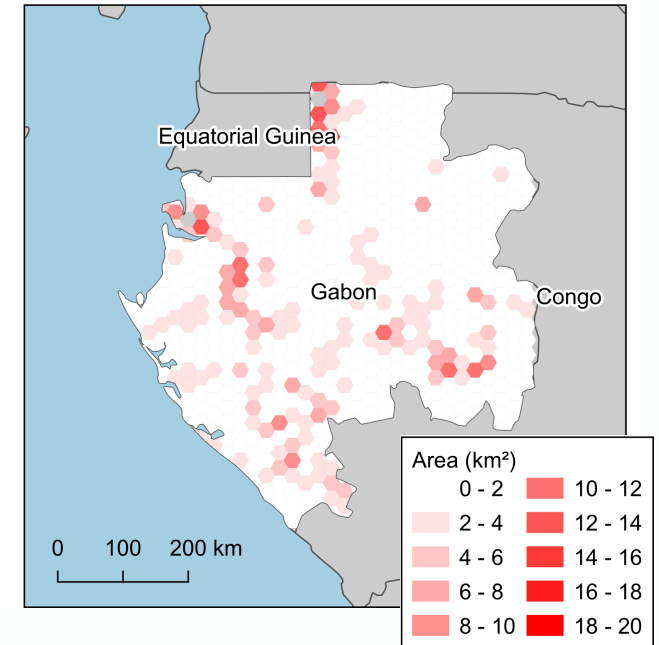
In 2022 we mapped 7 countries



Forest loss (2018-2021)



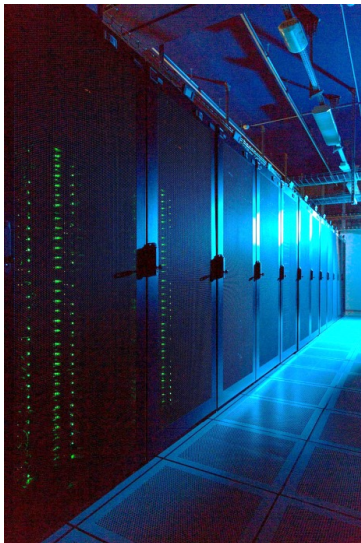
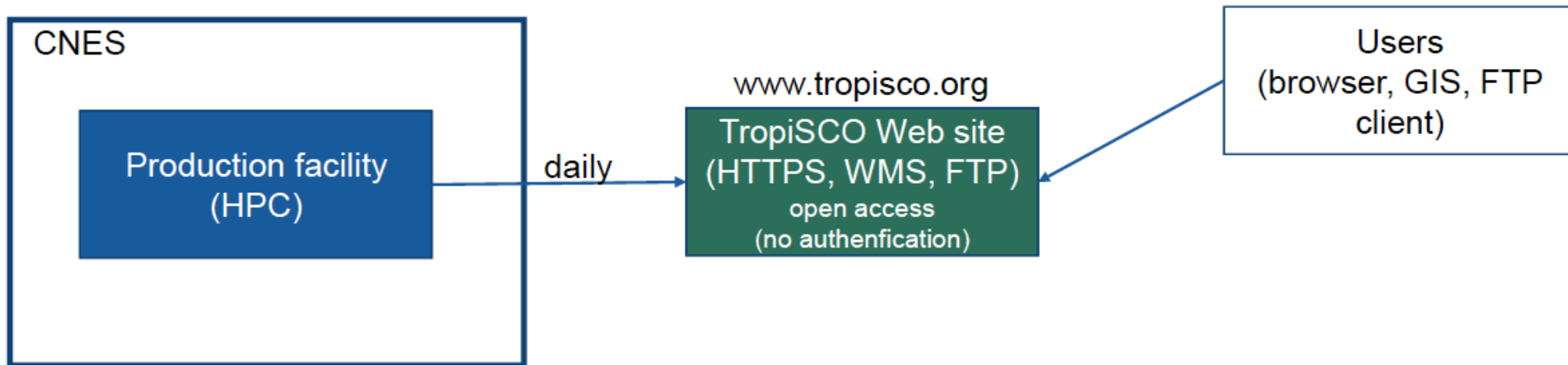
Hexagon surface = 460 km²



- 71 000 S1 images processed over South-East Asia

- Commission and omission errors of 10% and 0.9% (Mermoz et al., 2021)





CNES HPC facility

Every night, the TropiSCO processor :

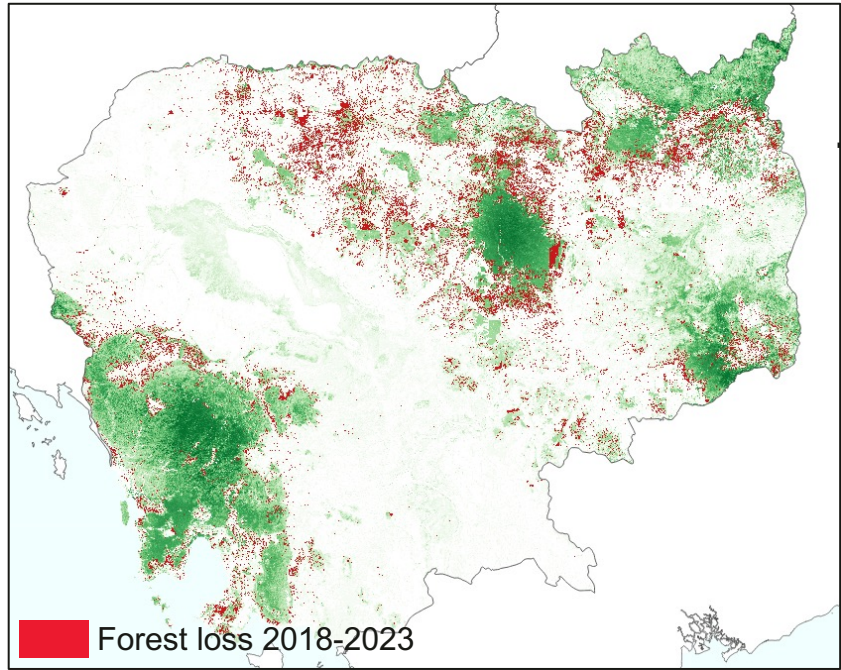
- process new Sentinel-1 images
- detects forest loss
- updates the forest loss maps and statistics
- transfers products to webGIS

Fully automatic process, same algorithms for all countries

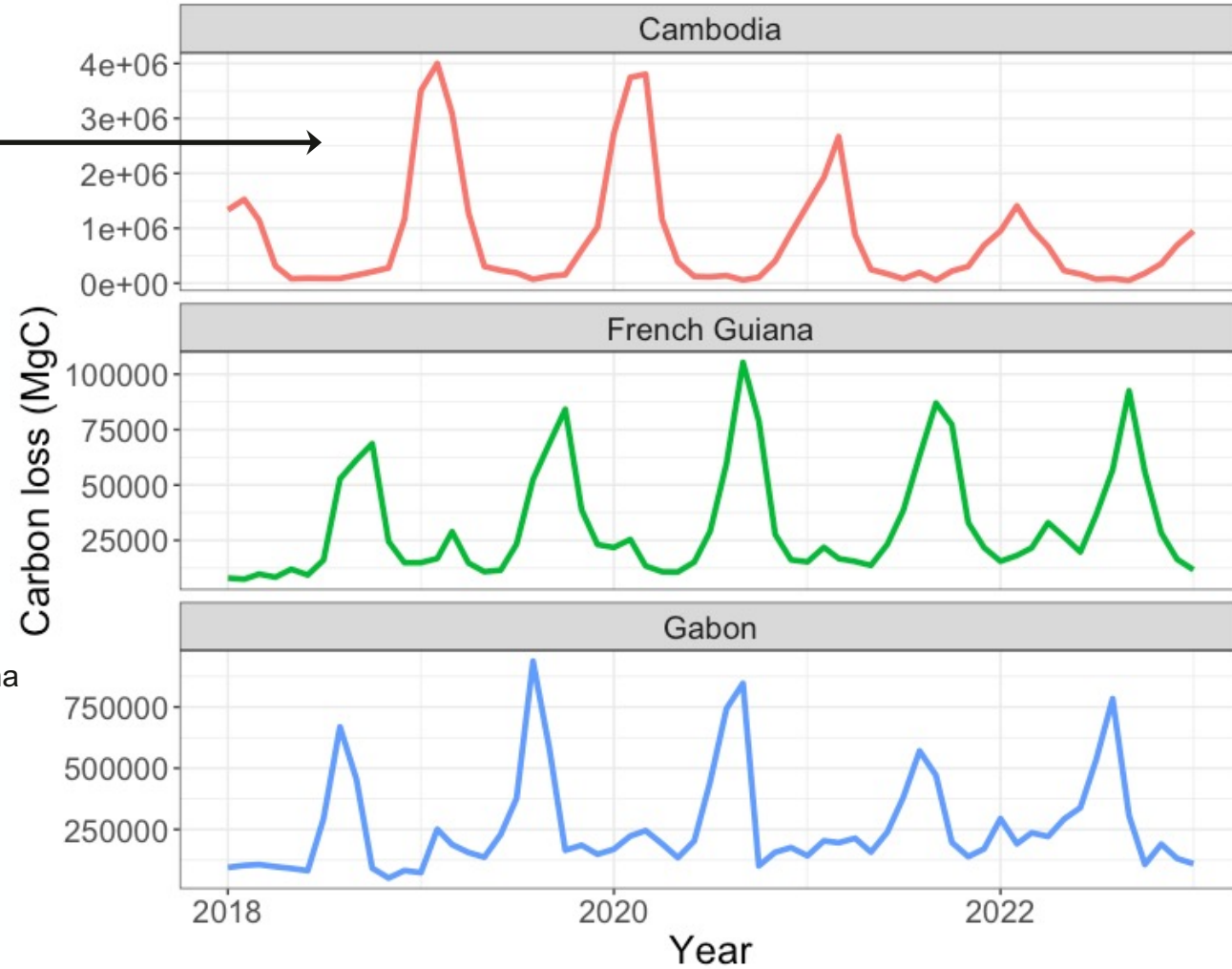
Carbon loss estimation



AGB x Forest loss areas



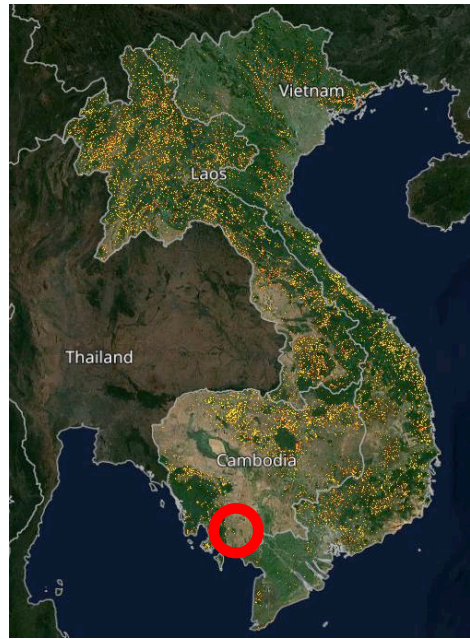
Carbon loss estimates

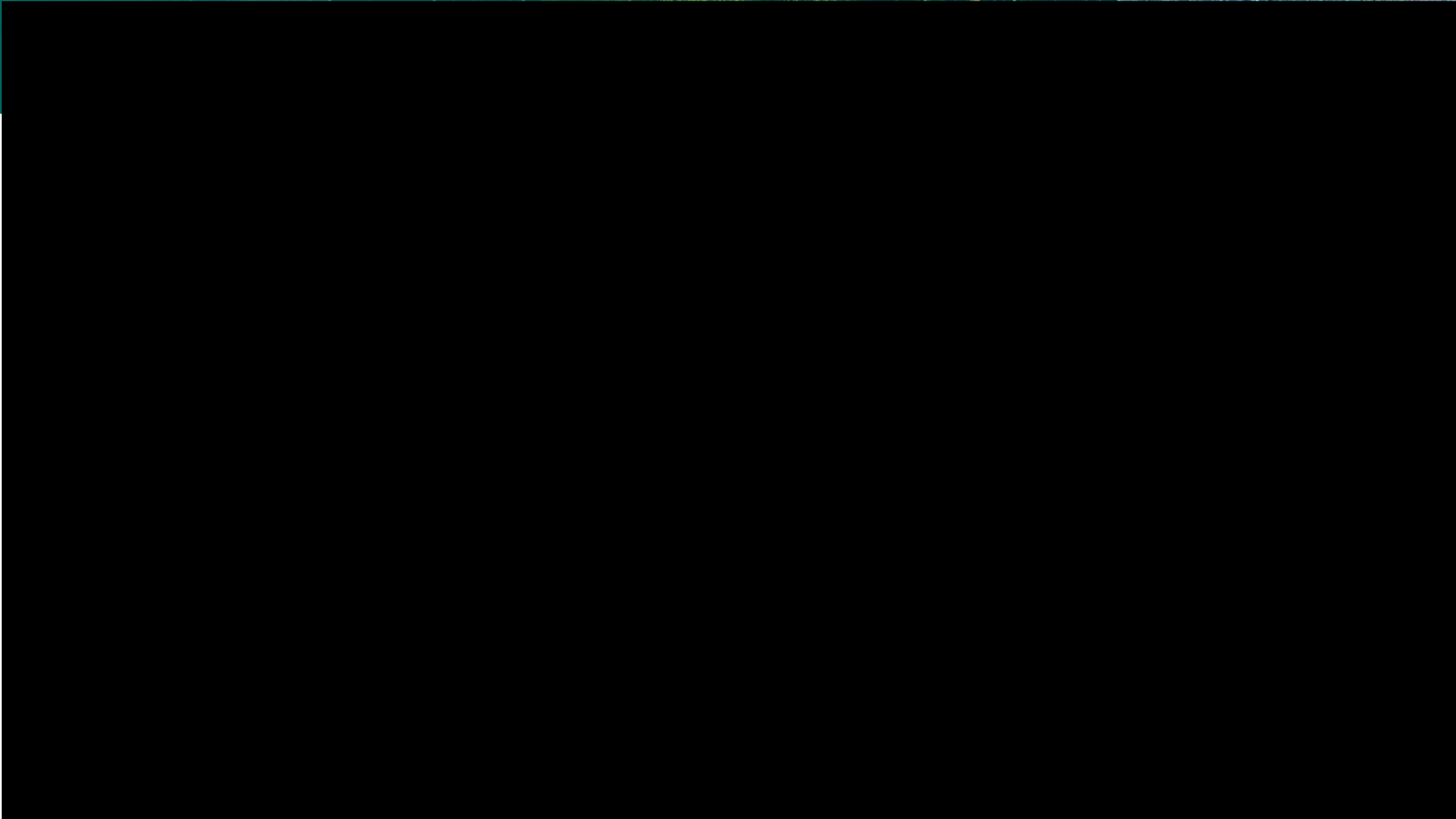


- Country
- Cambodia
 - French Guiana
 - Gabon



Study case in Cambodia in February 2023







MAP

DOWNLOAD

ABOUT



Search a country/city

GB



Explore



06/2017

Planet Layers

01/2023

5 km

South-east Asia

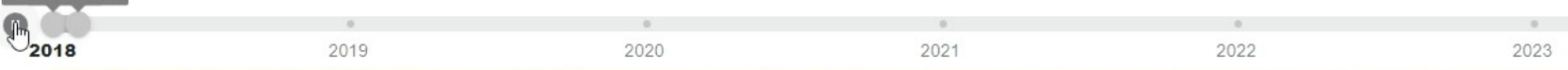
Gabon

Guiana Shield



Start date
01/01/2018

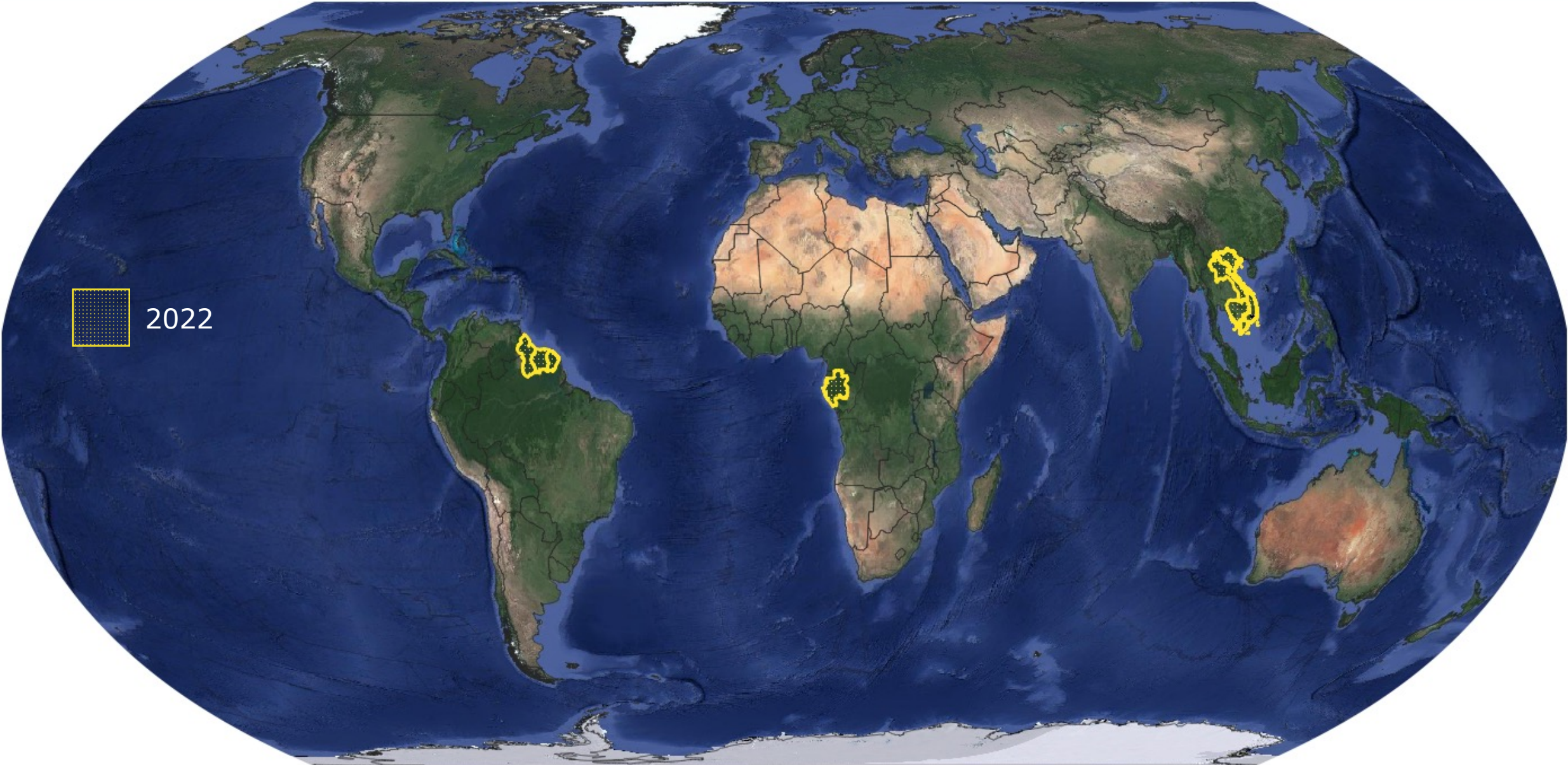
0 01/02/2018



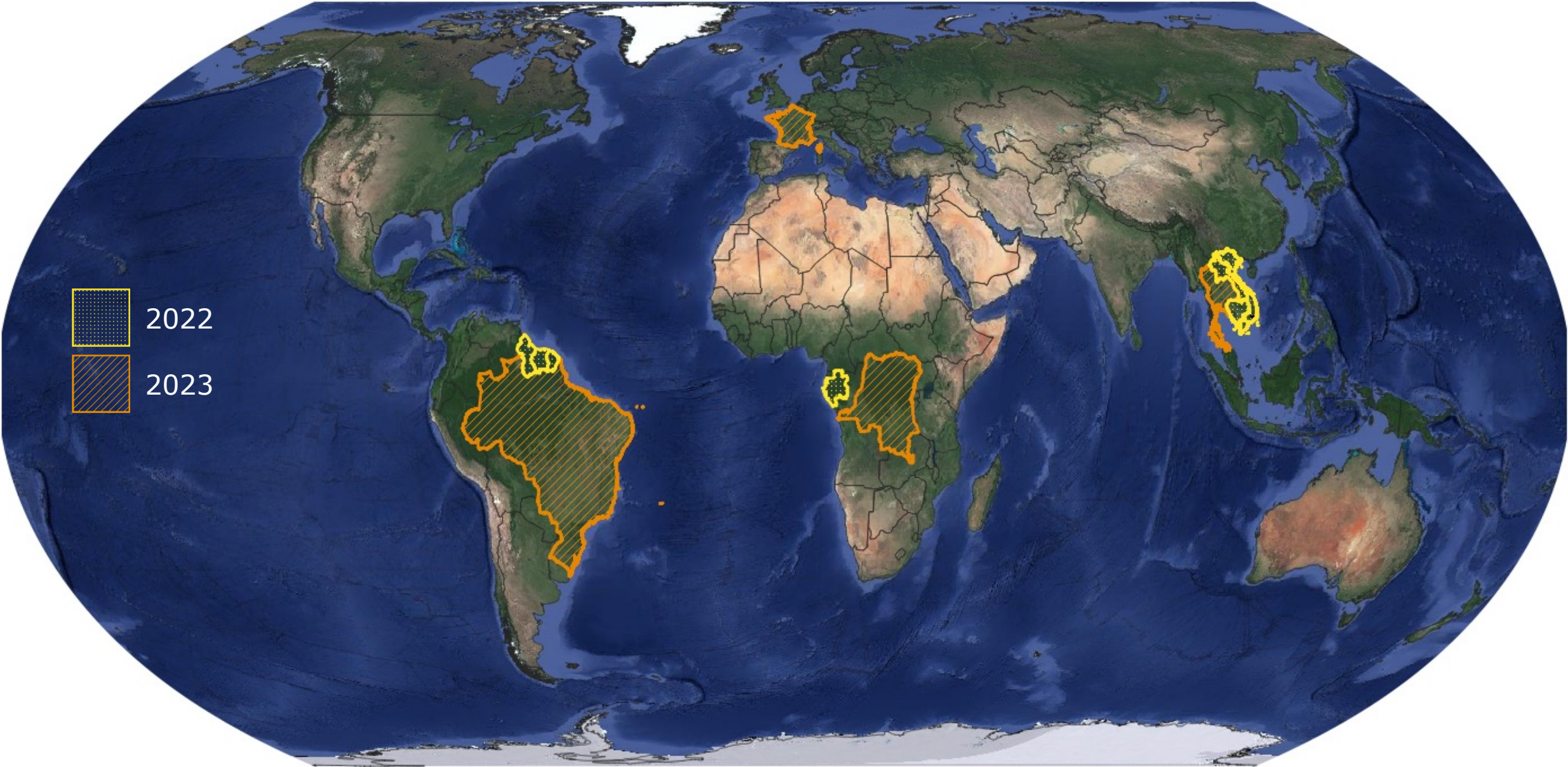
End date
26/02/2023

Confidence index
High

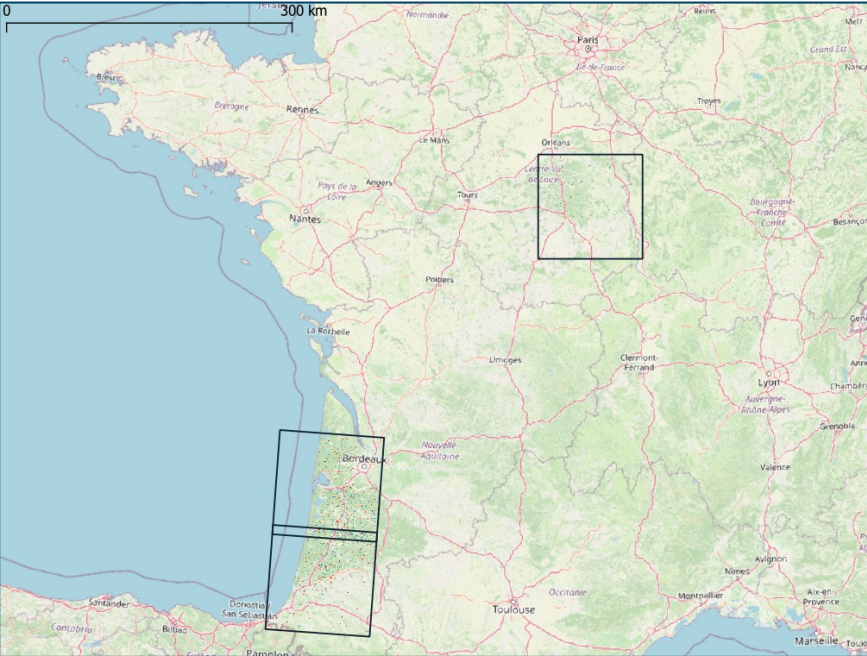
Coverage in 2022



Coverage planned in 2023



Results in France

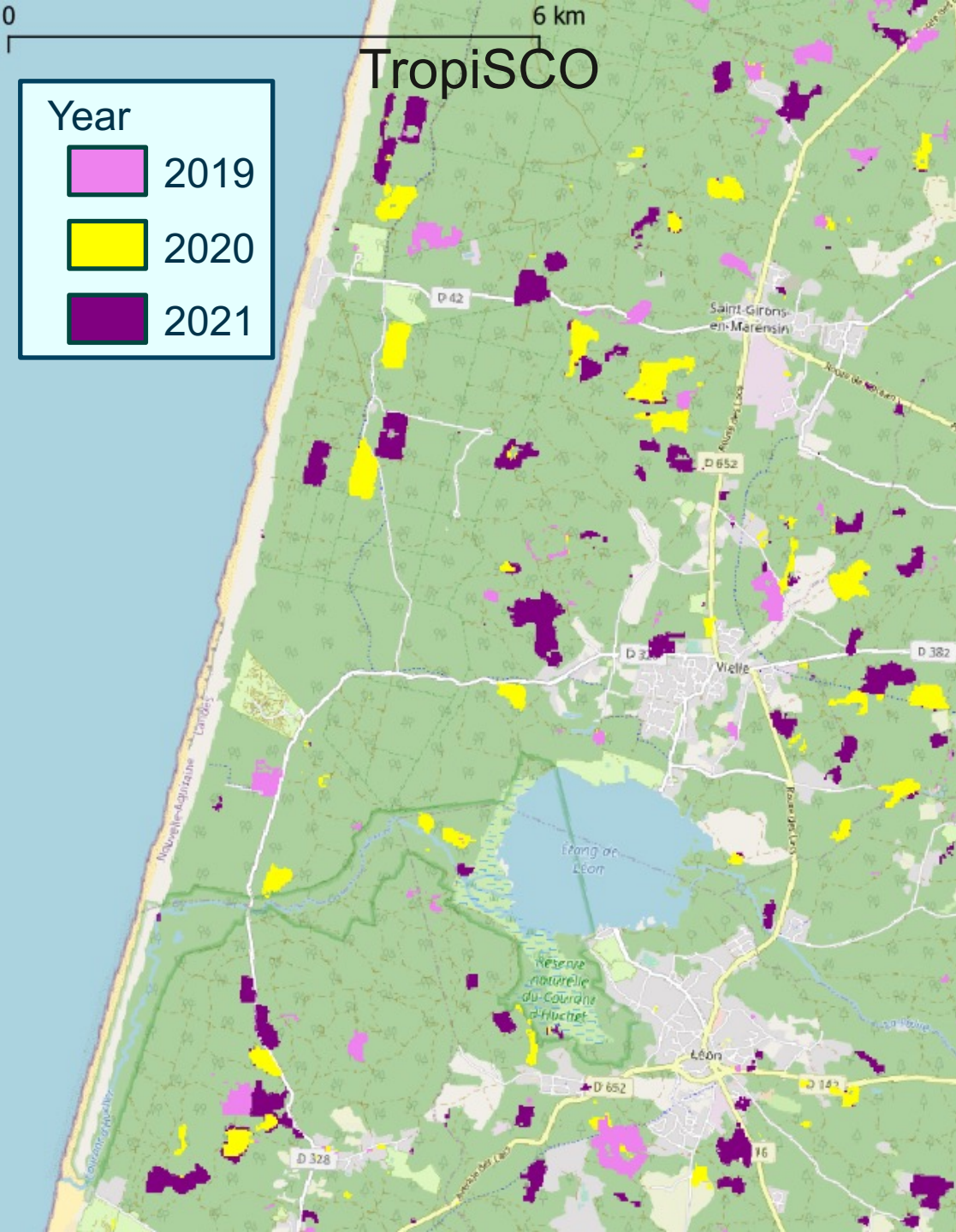




TropiSCO

Year

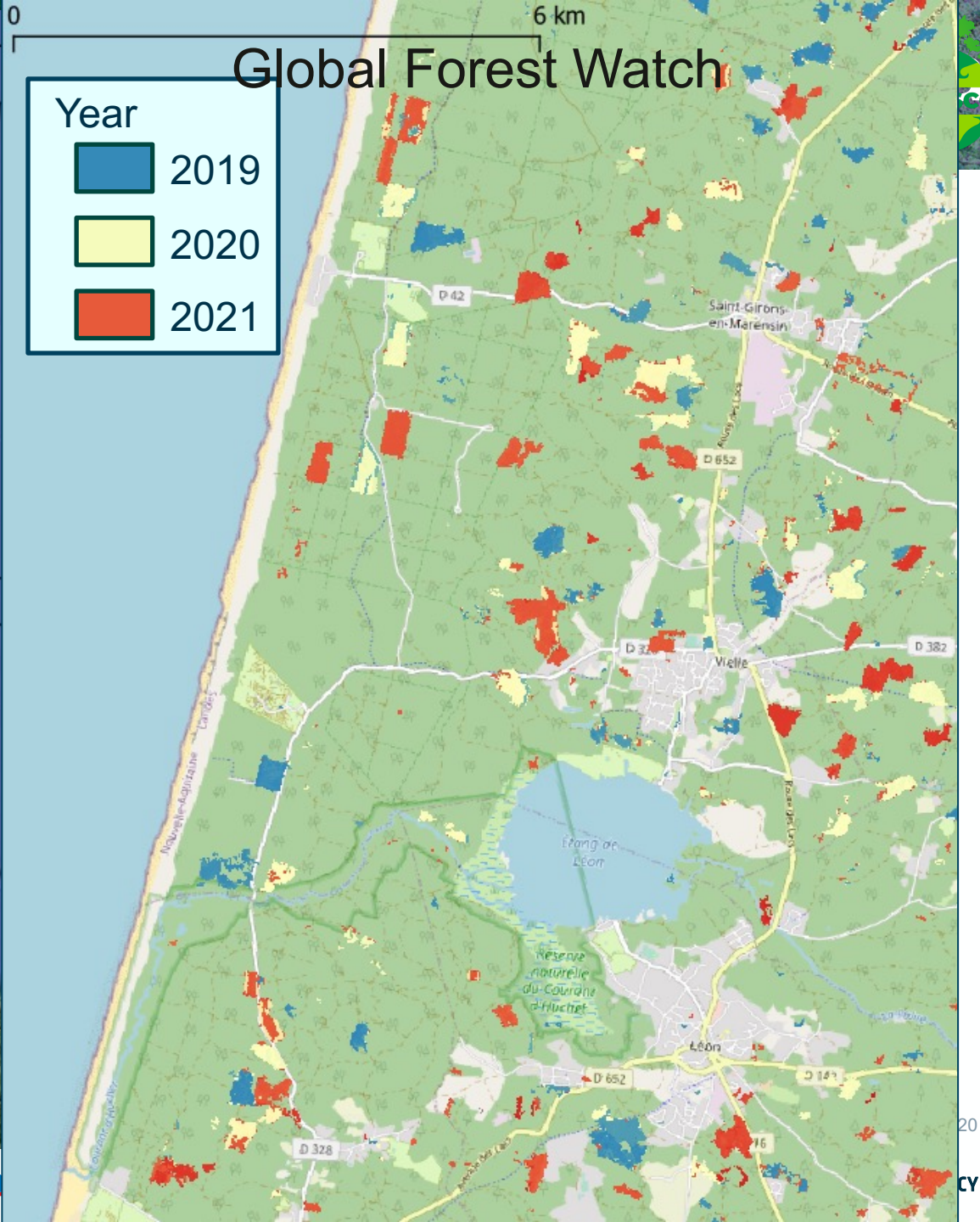
- 2019
- 2020
- 2021



Global Forest Watch

Year

- 2019
- 2020
- 2021



Coverage planned in 2023



- 2022
- 2023



Extension to Amazonia

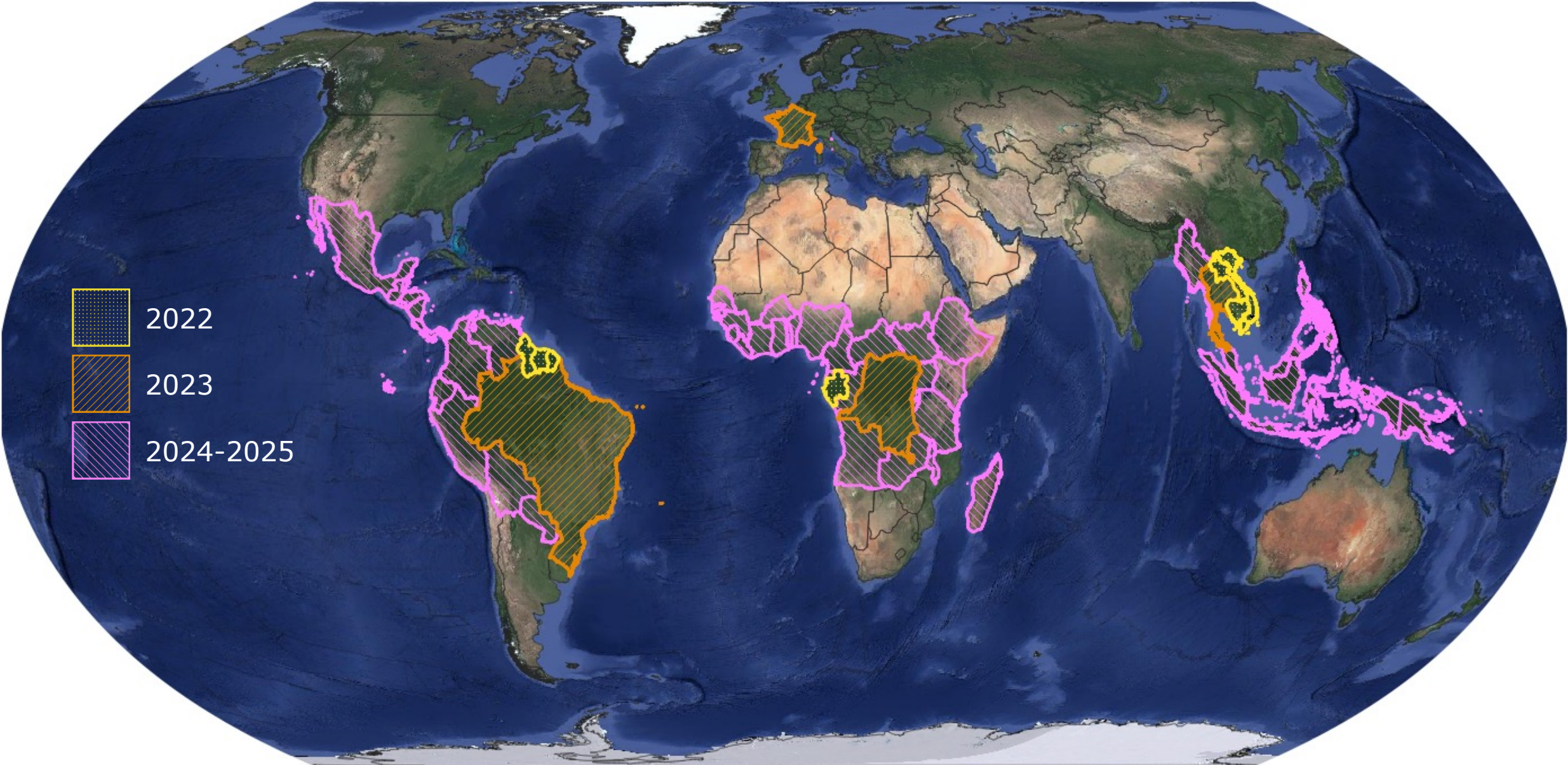


System	AC	MDK	CN	GUI
S2-Before				
S2-After				
GLAD-S2				
CESBIO				
INPE				
INPE-HR				
JJ-FAST				
RADD				

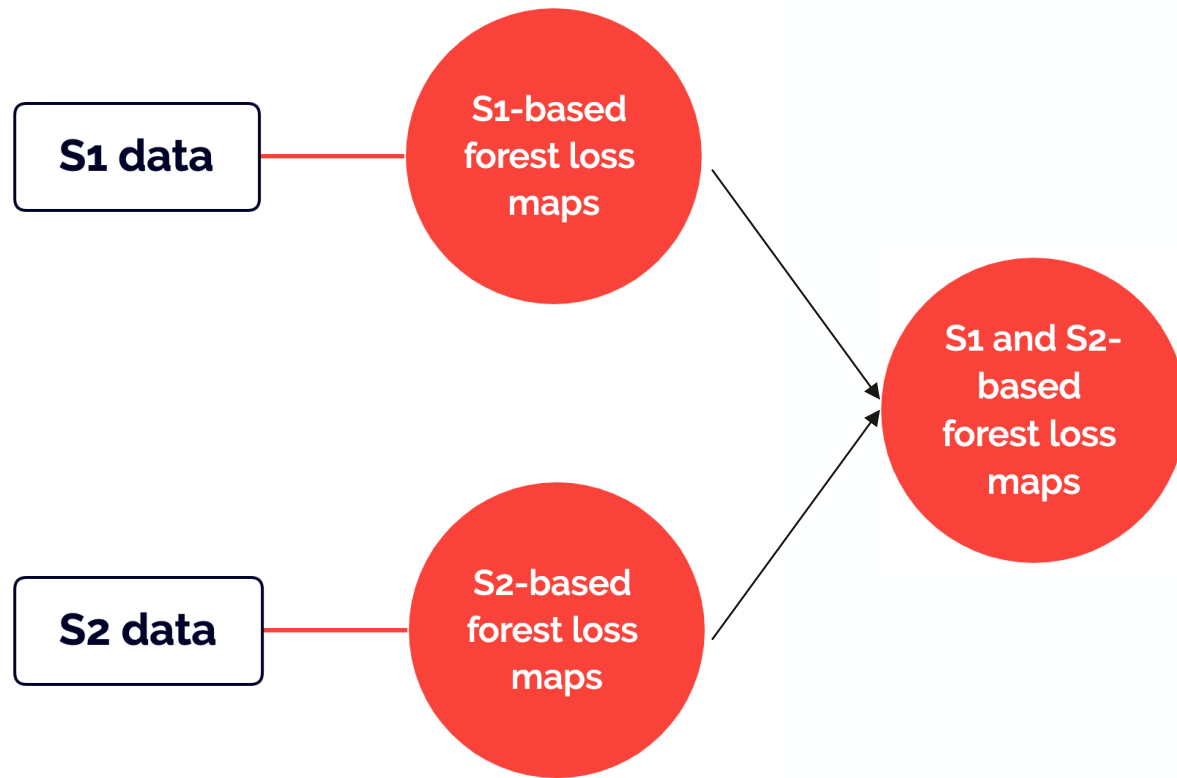
- Operational SAR and optical based detection systems have been compared in Amazonia (Doblas et al., 2023, IJRS)
- SAR-based tropical forest loss detection systems showed excellent detection accuracies, even in small, difficult-to-spot deforested patches (except for JJ-FAST)
- Complementaries among systems have been identified
- A new advanced alert system dedicated to Amazonia is being developed, taking advantage of TropiSCO and Deter-R, to map forest loss in Amazonia in an optimal manner



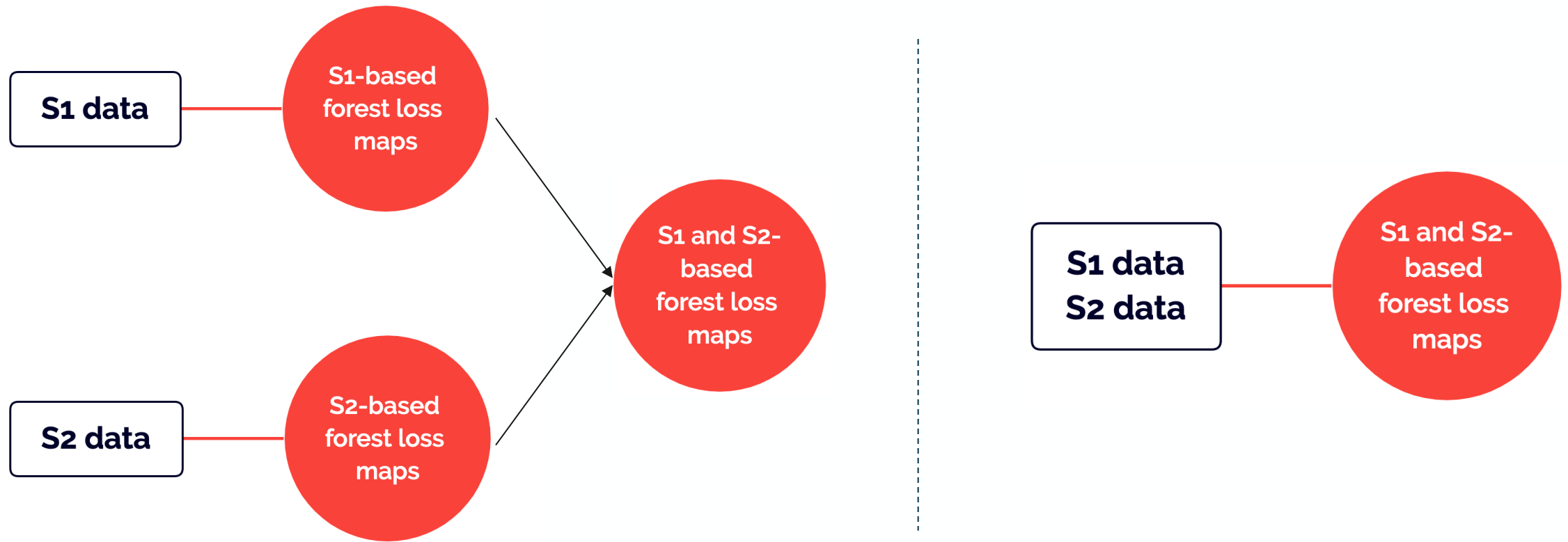
Coverage planned in 2024-2025



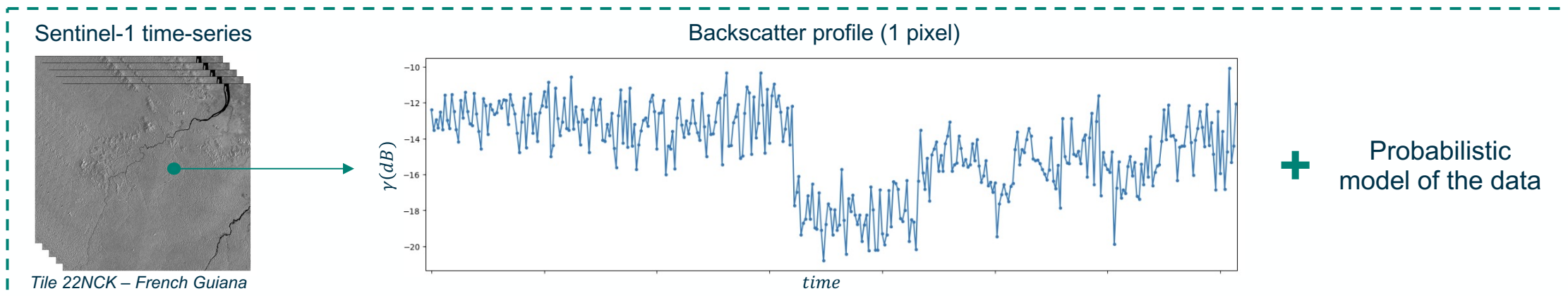
Detection with SAR and optical data



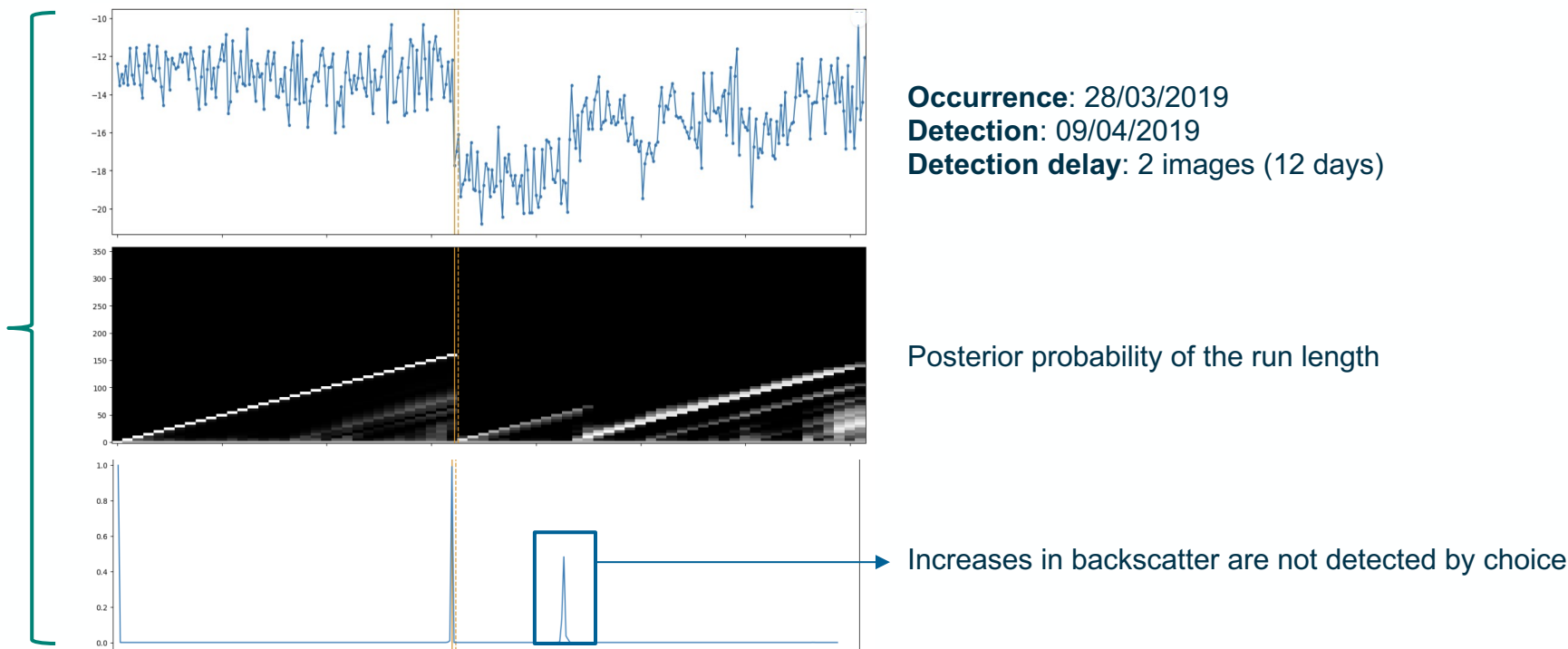
Detection with SAR and optical data



Detection with S1 and S2 data using Bayesian forest loss detection – Ph.D. Marta Bottani



Bayesian change detection

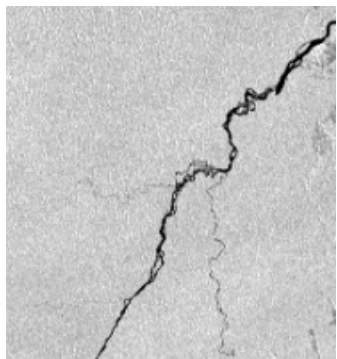


Detection with S1 and S2 data using Bayesian forest loss detection – Ph.D. Marta Bottani

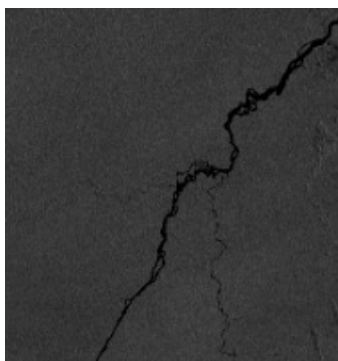
- **Univariate case** → the time-series is segmented based on changes in the mean and the variance
- **Multivariate case** → the time-series can be segmented based on changes in the mean, variance, and the correlation structure

Polarization diversity

VV + VH



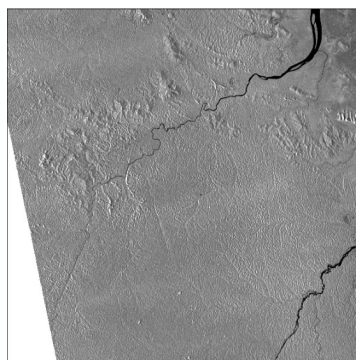
S1 - vv



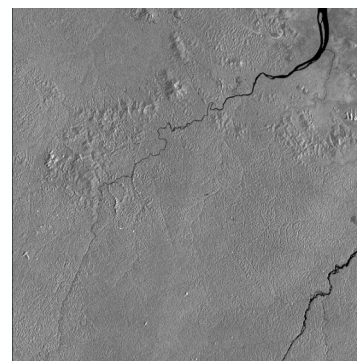
S1 - vh

Asynchronous sources

ASC + DES orbits



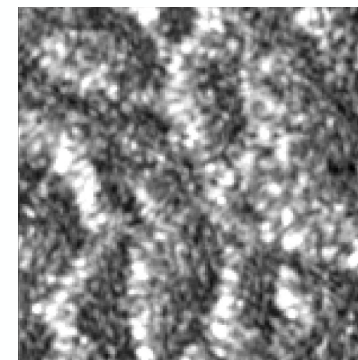
S1 - vh - ASC orbit



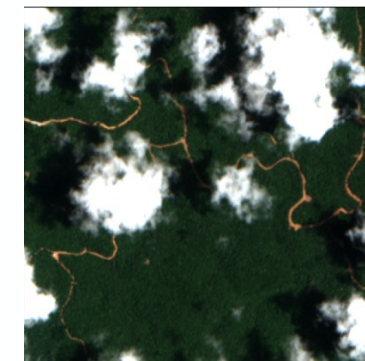
S1 - vh - DES orbit

Asynchronous sources + different sensor

Sentinel1 + Sentinel2



S1 - vh - ASC orbit



S2 - rgb

© Thierry Koleck



© ONF



© Juan Doblaz



© Stéphane Mermoz

