European Commission

High-resolution mapping of tropical moist forest cover dynamics over the last 30 years

Christelle Vancutsem[1], Frédéric Achard[1], Jean-Francois Pekel[1], Ghislain Vieilledent[2], Silvia Carboni[3], Dario Simonetti[1], Javier Gallego[1], Luiz Aragao[4]

[1] JRC
[2] CIRAD
[3] GFT
[4] INPE

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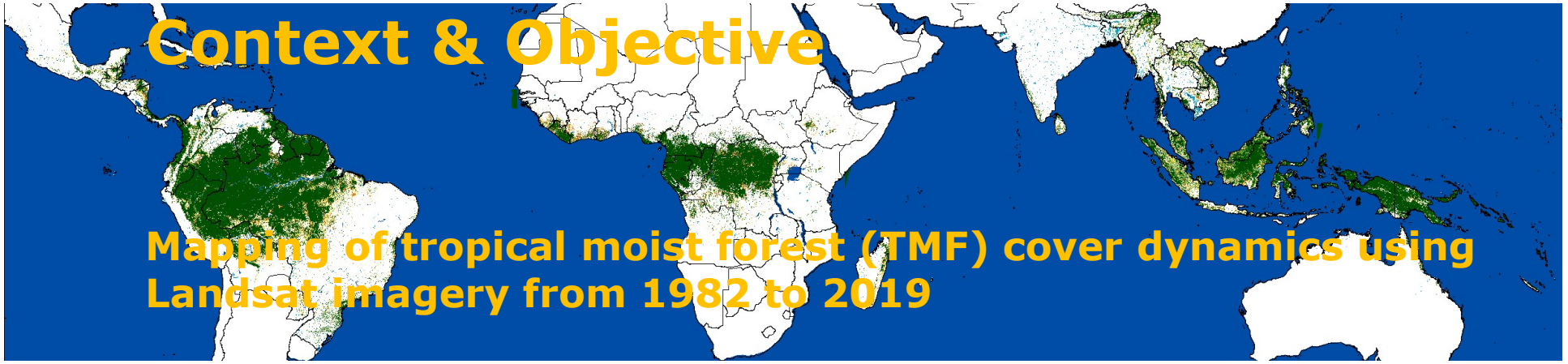
Context & Objective



Mapping of tropical moist forest (TMF) cover dynamics using Landsat imagery from 1982 to 2019

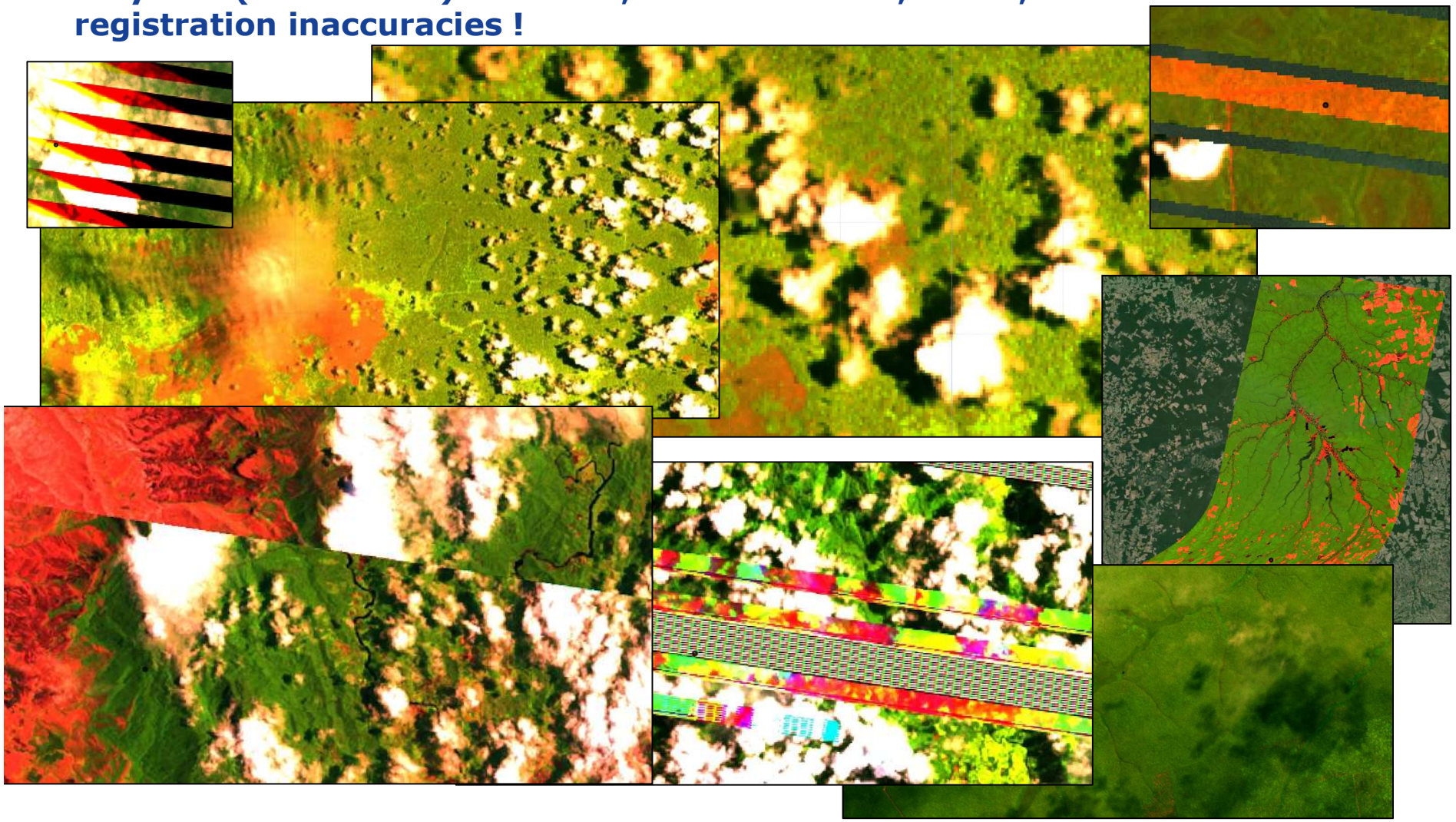
- Initially developed within EU project funded by DG CLIMA – ROADLESS Forest Project
- Accurate mapping and characterization of long-term forest disturbances (deforestation and degradation) over pan-tropical areas is needed to support global conservation policies and to accurately quantify their contribution to global carbon fluxes
- Limited information exists on the evolution of TMF extent and degradation, on successional stages and on the characterization of changes over a long-time period

A new mapping approach has been developed using the full Landsat archive available (L4,L5,L7,L8) from 1982 to capture transition stages and annual changes (deforestation and degradation) within the tropical moist forest (TMF) at 30m resolution over the last 30 years

Every single cloud-free Landsat pixel has been exploited in order to capture short events (such as selective logging activities) and disturbances timing and intensity

Challenges

38 years (1982-2019) of clouds, cloud shadows, hazes, sensor artefacts and registration inaccuracies !



→ Required a good understanding of the multi-spectral signatures of the various land cover types and noise (by collecting of 38326 sampled pixels)

Challenges

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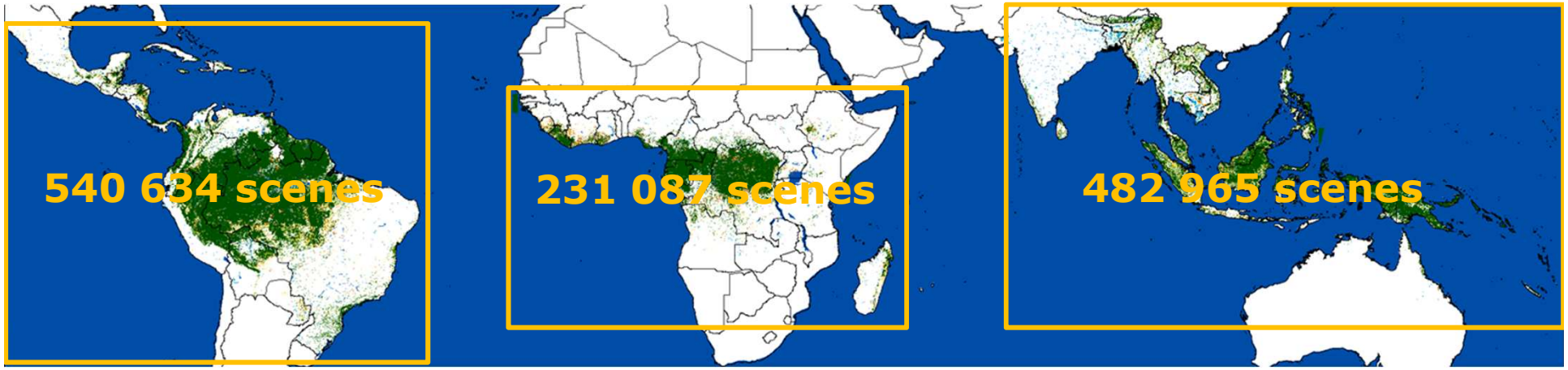
Landsat archive presents large geographical and temporal unevenness

Number of Landsat acquisitions (~1 250 000 scenes)



Challenges

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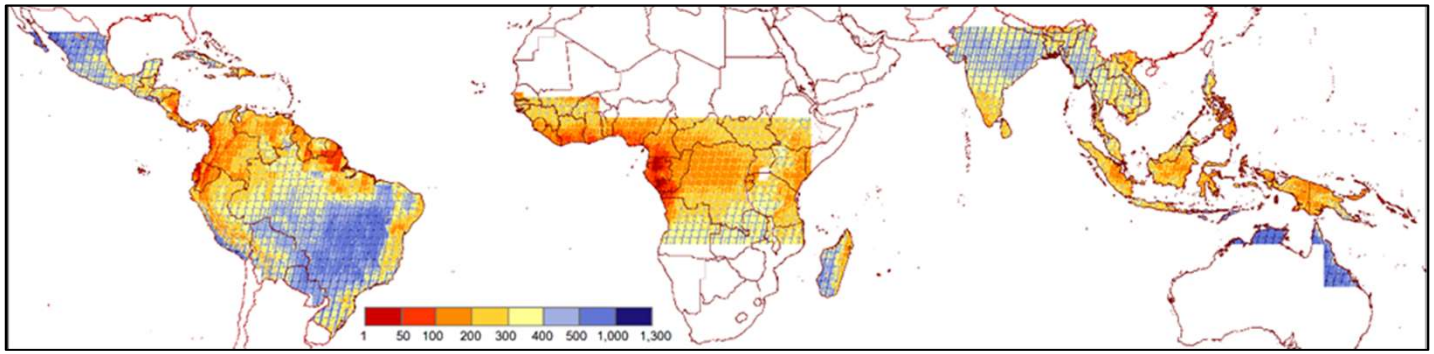
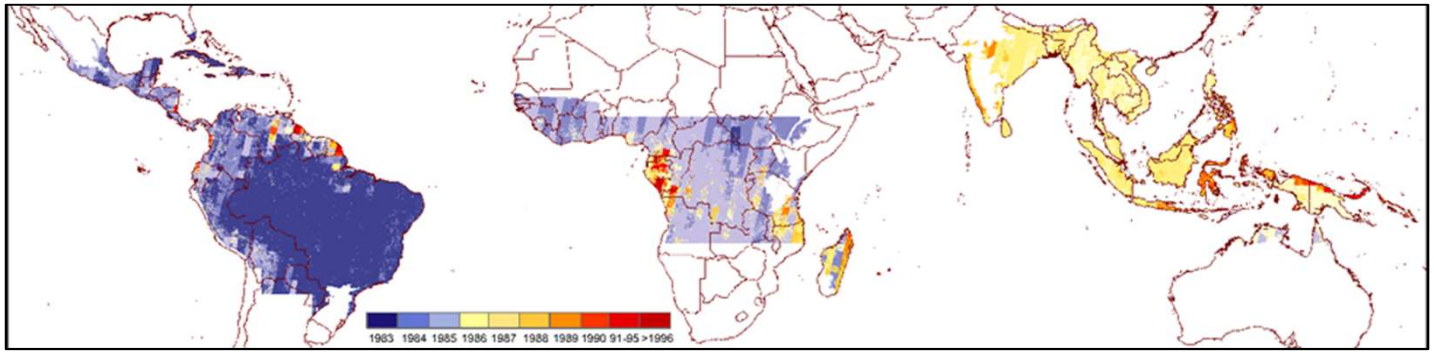
Landsat archive presents large geographical and temporal unevenness

Total number of valid observations (1982-2018)



First year with a valid observation



Effective monitoring period considerably varies from one pixel to another

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Mapping Method

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Expert system

- Sequential decision tree
- Exploits the multispectral and multitemporal attributes of the Landsat archive
- Uses ancillary information (GSWE, Mangrove Extent, Tree Plantations) and VHR visual interpretation
- Baseline to identify the initial TMF domain

Processing sequence

1. Single-date classification
2. Temporal classification
3. Identification of sub-classes
4. Production of annual change maps

Platform

Google Earth Engine

Mapping Method

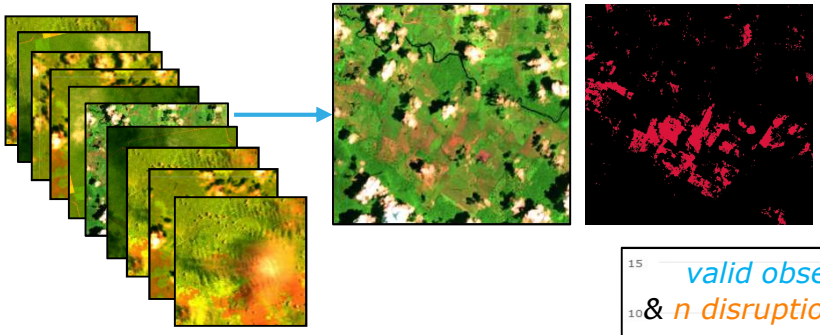
European Commission

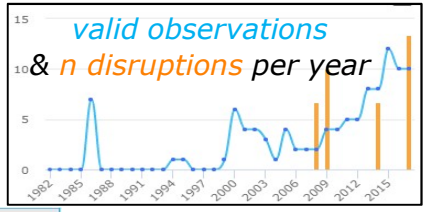
1. Single-date classification

Important for capturing short-duration events (logging) and characterizing disturbances (timing and number of disruptions)

1 254 686 Landsat scenes

Identification of valid observations and potential disruptions using multi-spectral library (38 326 sampled pixels)



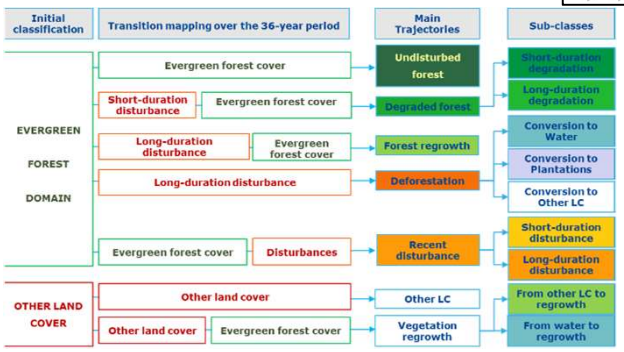


2. Temporal classification

- Initial extent of the tropical moist forest
- Identification of the main transition classes

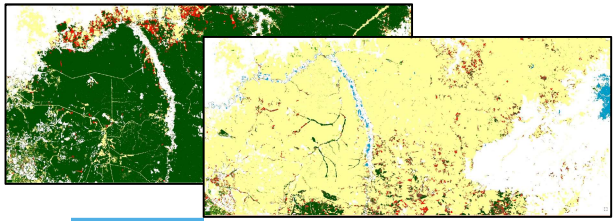
3. Identification of sub-classes

- Using timing (dates, duration) and Intensity
- Using ancillary information completed by visual interpretation of high-resolution



4. Production of annual change maps

Document the extent of the tropical moist forest and disturbances for each year



Mapping Method

Temporal classification

- Dynamic baseline and monitoring period (per pixel) to limit constraints that are intrinsically related to the specificities of the Landsat archive
- Initial classification to identify the extent TMF domain (baseline), lasts min. 3 years
- Decision rules applied on the sequence of single-date classifications (valid observations and potential disruptions) using the following metrics:
  - Timing (dates, duration)
  - Intensity (n disruptions)
  - Recurrence (n years disturbed / duration)
- Identification of 5 main change trajectories & sub-classes
- Identification of sub-classes using ancillary information and visual interpretation of HR
  - Global Surface Water Explorer (GSWE) (Pekel et al. 2016)
  - Global Mangrove Watch Max Extent 1996-2016 (Bunting et al. 2018)
  - Tree plantation datasets (Petersen et al. 2016, Vijay et al. 2016, Harris et al. 2019)

Temporal classification

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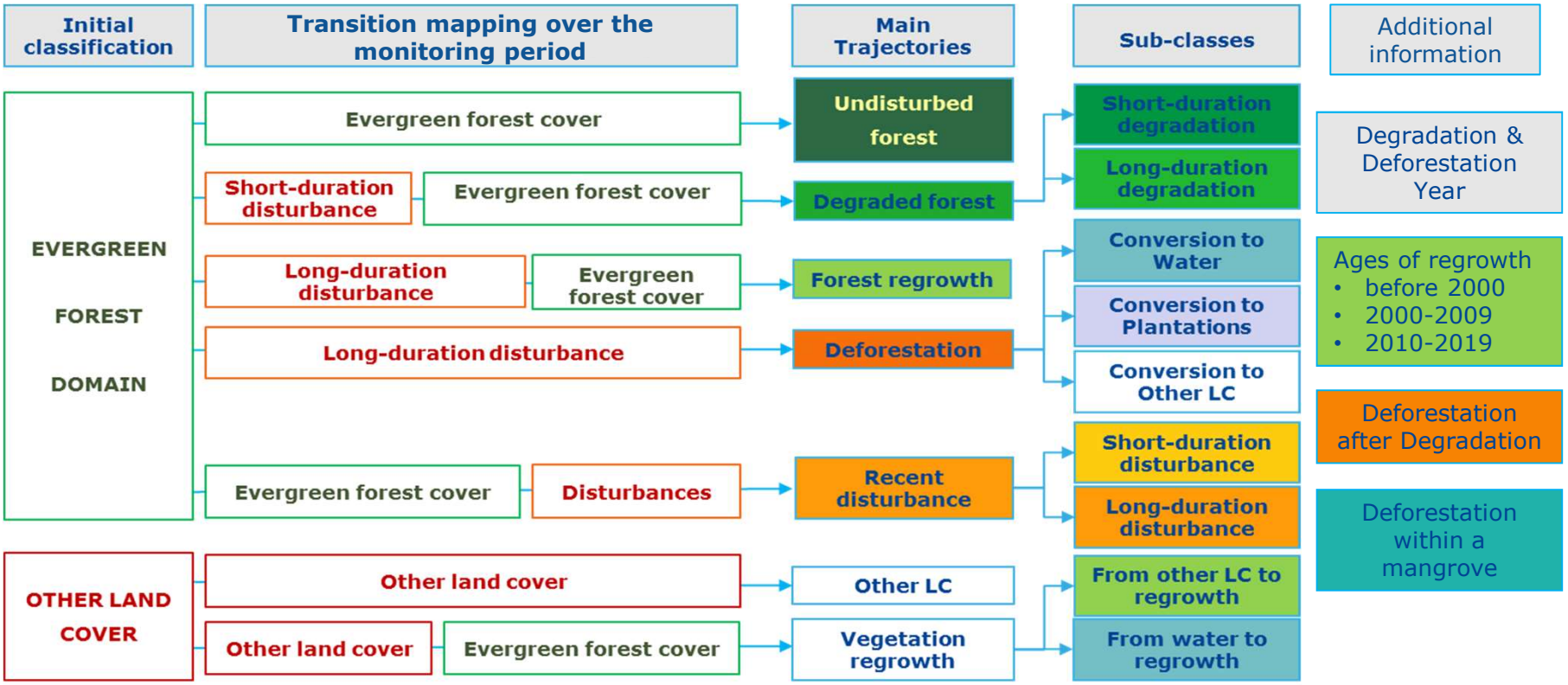
Identification of 5 main change trajectories & sub-classes using timing, intensity, and recurrence of disturbances



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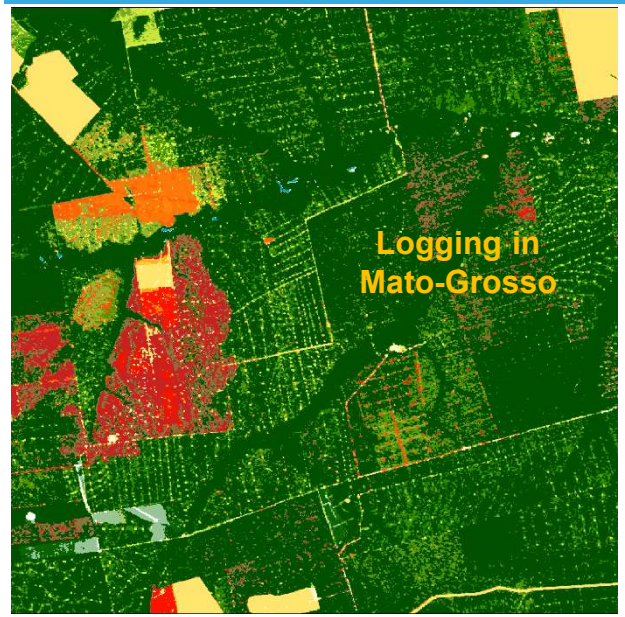
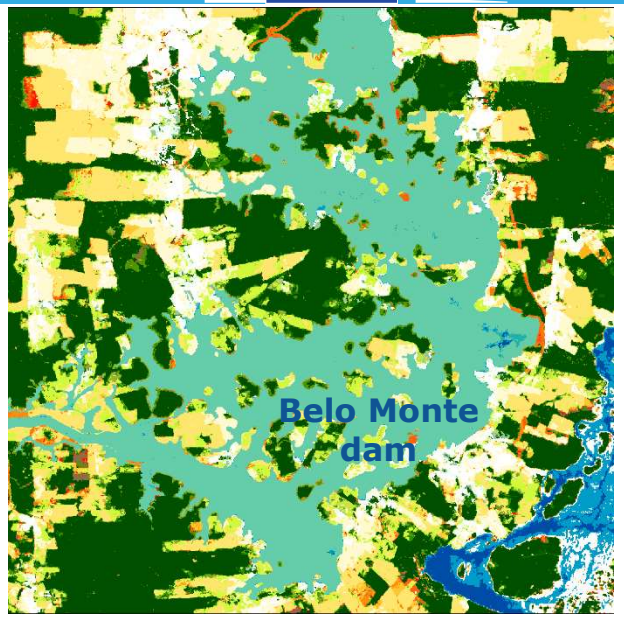
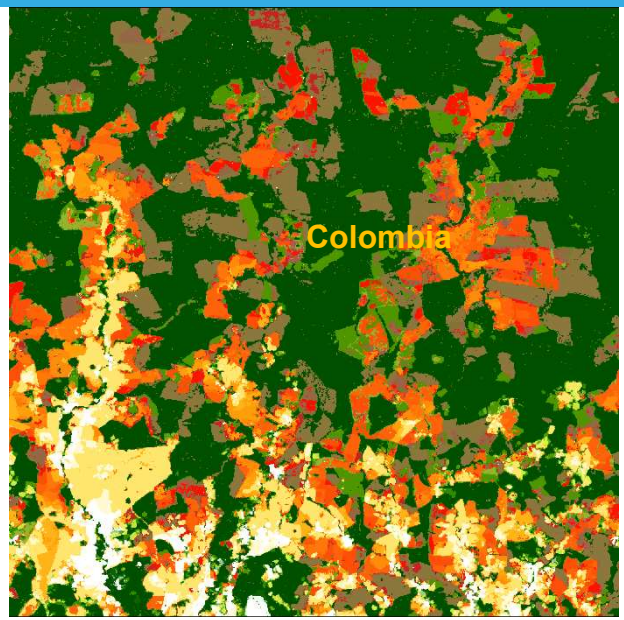
Transition map

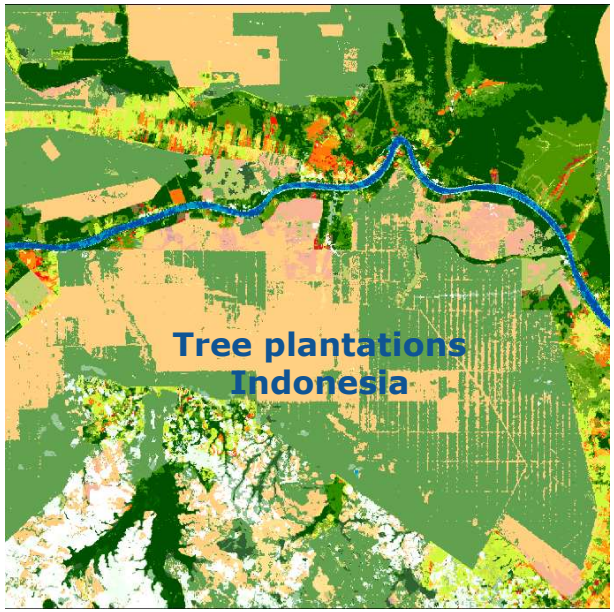
Patterns of forest cover disturbances (deforestation and degradation)

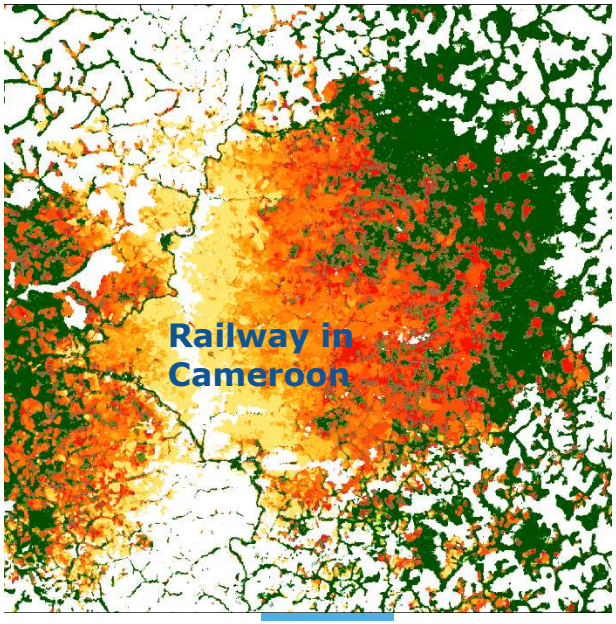
- Undisturbed forest
- Slightly degraded forest
- Severely degraded forest
- Forest regrowth
- Deforestation started in 1982-2005
- Deforestation started in 2006-2014
- Strong disturbances started in 2015-2017
- Light disturbances started in 2016-2017
- Seasonal and permanent water
- Deforestation to water
- Old to young plantations
- Deforestation within the plantations

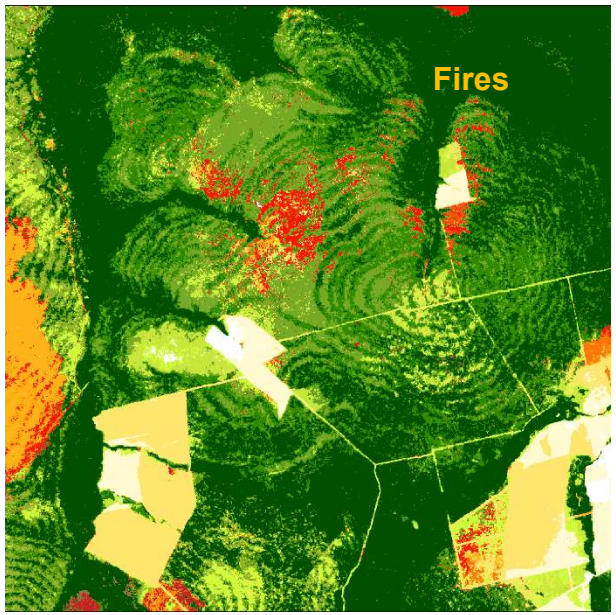








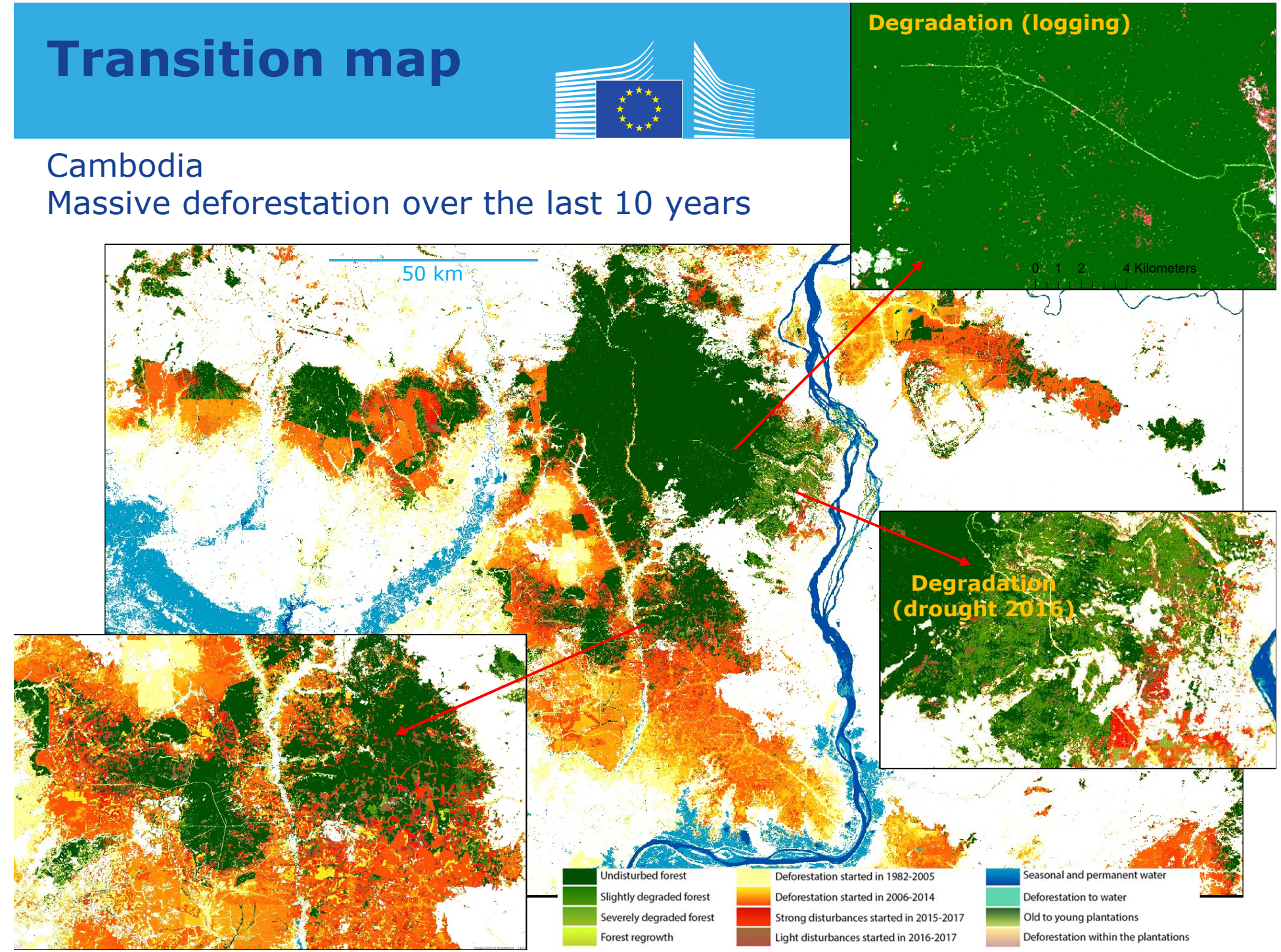




20 km

Transition map

Cambodia
Massive deforestation over the last 10 years



Transition map

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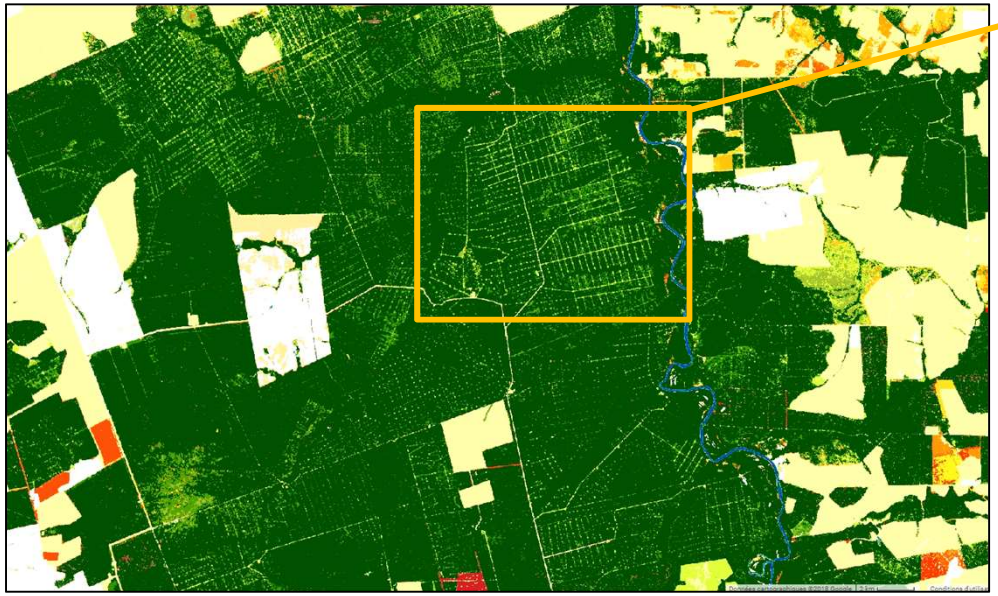
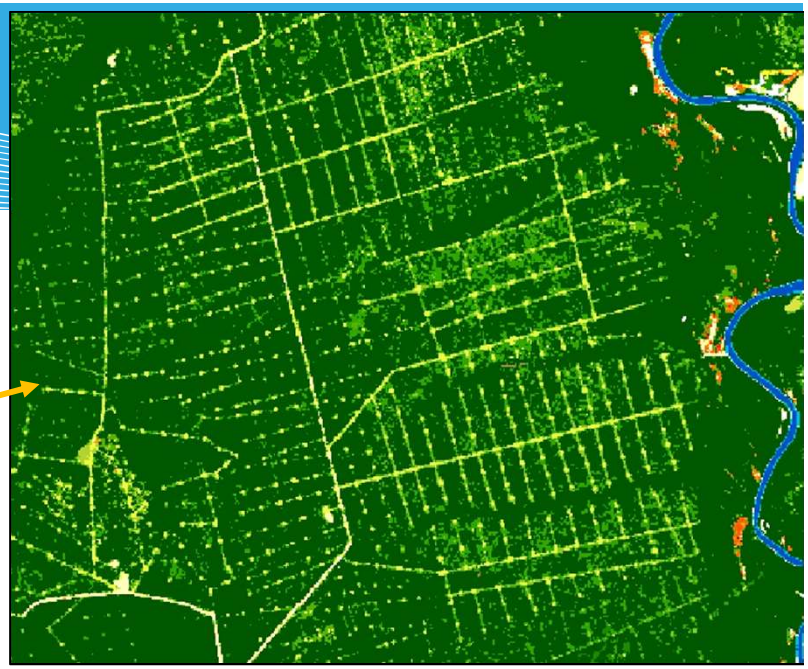
Brazil - Mato Grosso (Sinop)

Skid trails & logging decks

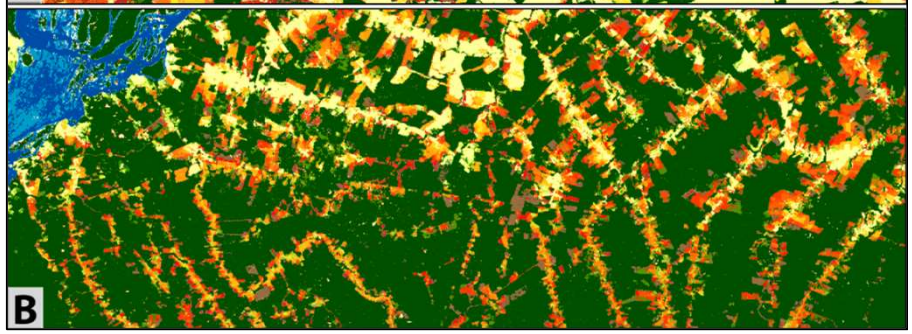




16 km

Roraima

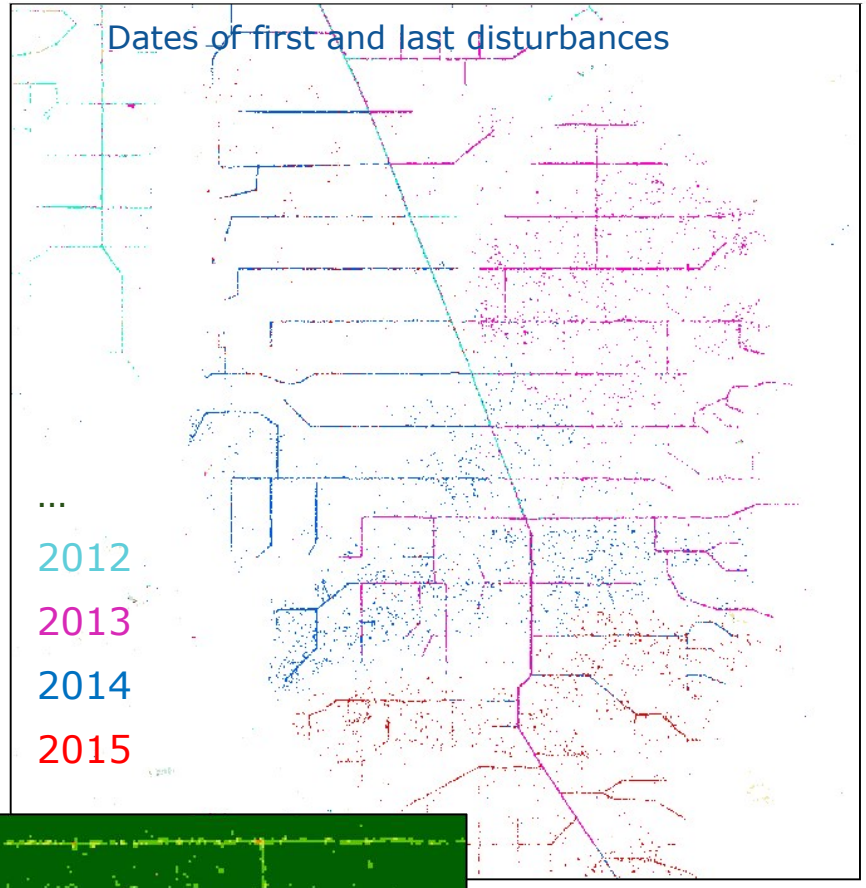
Para

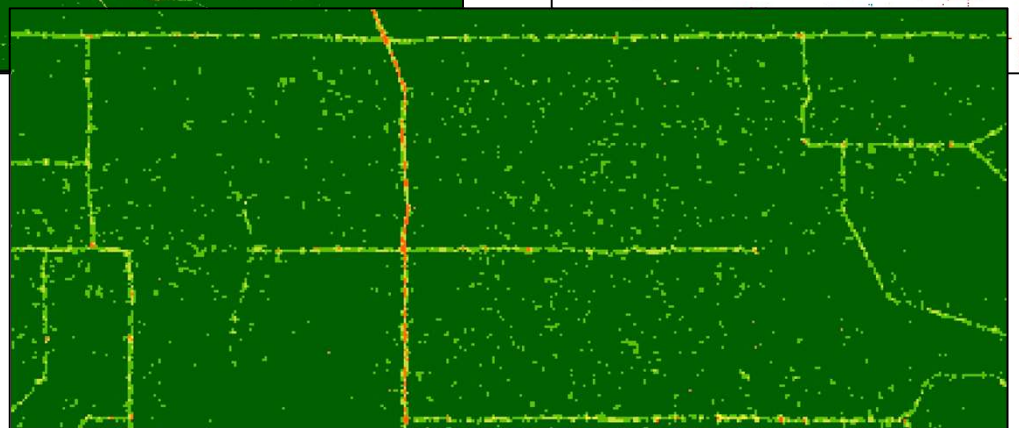


50 km

- Undisturbed forest
- Slightly degraded forest
- Severely degraded forest
- Forest regrowth
- Deforestation started in 1982-2005
- Deforestation started in 2006-2014
- Strong disturbances started in 2015-2017
- Light disturbances started in 2016-2017
- Seasonal and permanent water
- Deforestation to water
- Old to young plantations
- Deforestation within the plantations

Transition map
Selective logging





Undisturbed forest
Slightly degraded forest
Severely degraded forest
Forest regrowth
Deforestation started in 1982-2005
Deforestation started in 2006-2014
Strong disturbances started in 2015-2017
Light disturbances started in 2016-2017
Seasonal and permanent water
Deforestation to water
Old to young plantations
Deforestation within the plantations

Republique du Congo

Collection of annual change maps

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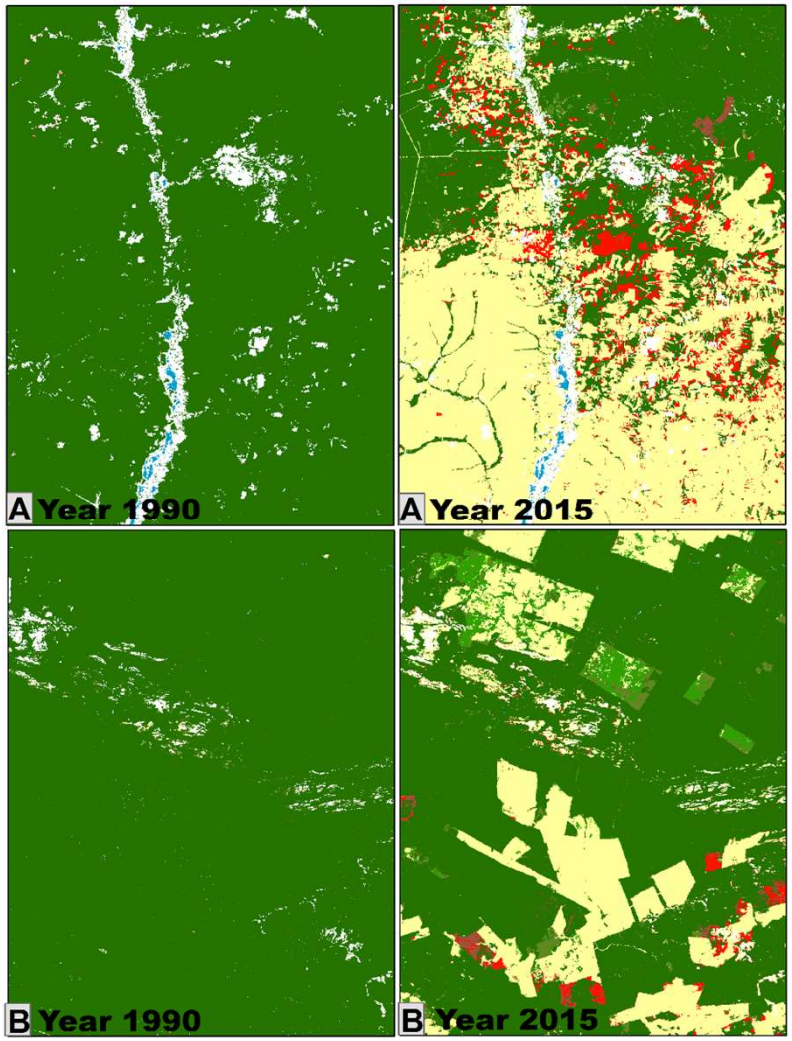
For each year between 1990 and 2019, we provide the spatial extent of the evergreen forest and disturbance (deforestation, degradation and regrowth)



Collection of annual change maps

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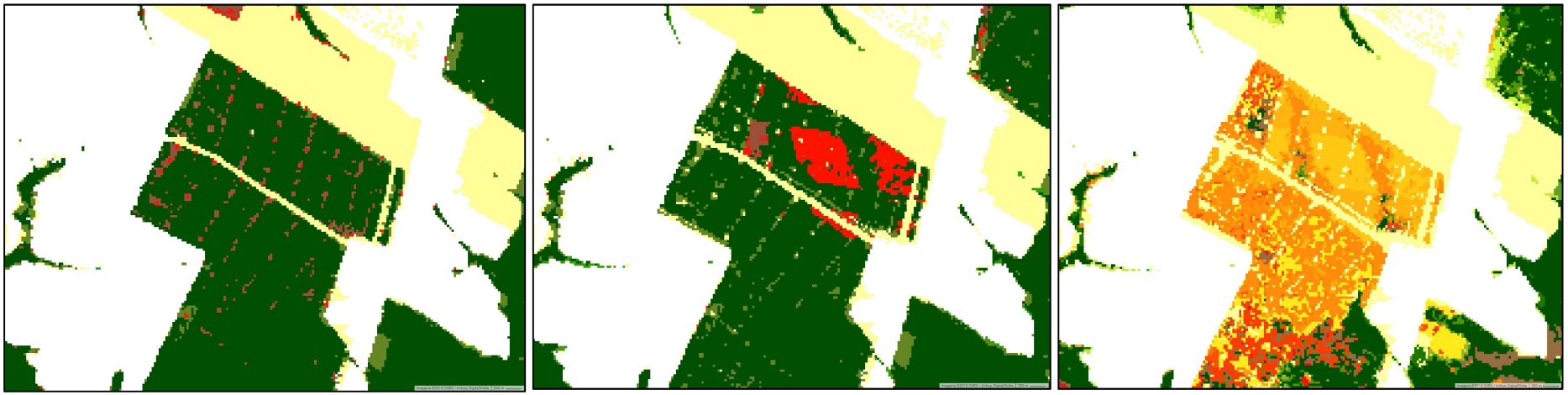
The annual change collection shows the evolution of annual deforestation and degradation, and captures all successional stages such as degradation followed by deforestation :

Year 1999 **Year 2008** **Year 2018**



Annual change collection **Transition map**

Annual Change

1. Undisturbed evergreen tropical forest
2. Evergreen forest within the plantation area
3. New degradation
4. Ongoing degradation
5. Degraded forest
6. New deforestation
7. Ongoing deforestation
7. Ongoing deforestation
8. New regrowth
9. Regrowthing
10. Other land cover (not water)
11. Permanent Water (Pekel et al. 2016)
12. Seasonal Water (Pekel et al. 2016)

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Conclusions & perspectives

- Wall-to-wall map of tropical evergreen forest cover dynamics at 30-meter resolution
  - Classification of change trajectories (regrowth, deforestation, degradation)
  - Annual extent of the tropical moist forest, remaining and disturbed
  - Discrimination between deforestation and degradation
  - Characterization of disturbances by their timing, intensity and sequential dynamics
  - Identification of tree plantations & changes within the plantation areas,
  - Identification of the conversion from forest to water (e.g. creation of a dam)
  - Identification of the mangroves extent, remaining and disturbed for each year

- Validated product (91% of overall accuracy – stratified systematic sampling scheme - visual interpretation of 12,235 images)

- The use of every valid pixel over a long time period allows minimizing commission errors (with agriculture areas) and capturing more disturbances (logging and deforestation)

- Input for sustainable management, biodiversity conservation, quantification of annual loss in above-ground stock

- All the dataset will be publicly available for visualization and download

- The maps are regularly updated with Landsat and the methodology will be adapted to Sentinel2 (Roadless2 project-DG CLIMA)

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For further information, please contact:

Christelle.VANCUTSEM@ec.europa.eu