



# Tropical Moist Forest Monitoring

**10TH ADVANCED TRAINING COURSE ON LAND  
REMOTE SENSING**

**22-09-2021**

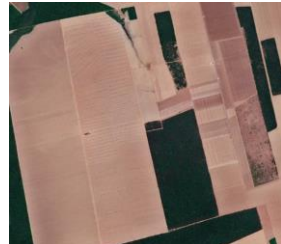
*Clément Bourgoin*

*JRC.D1*

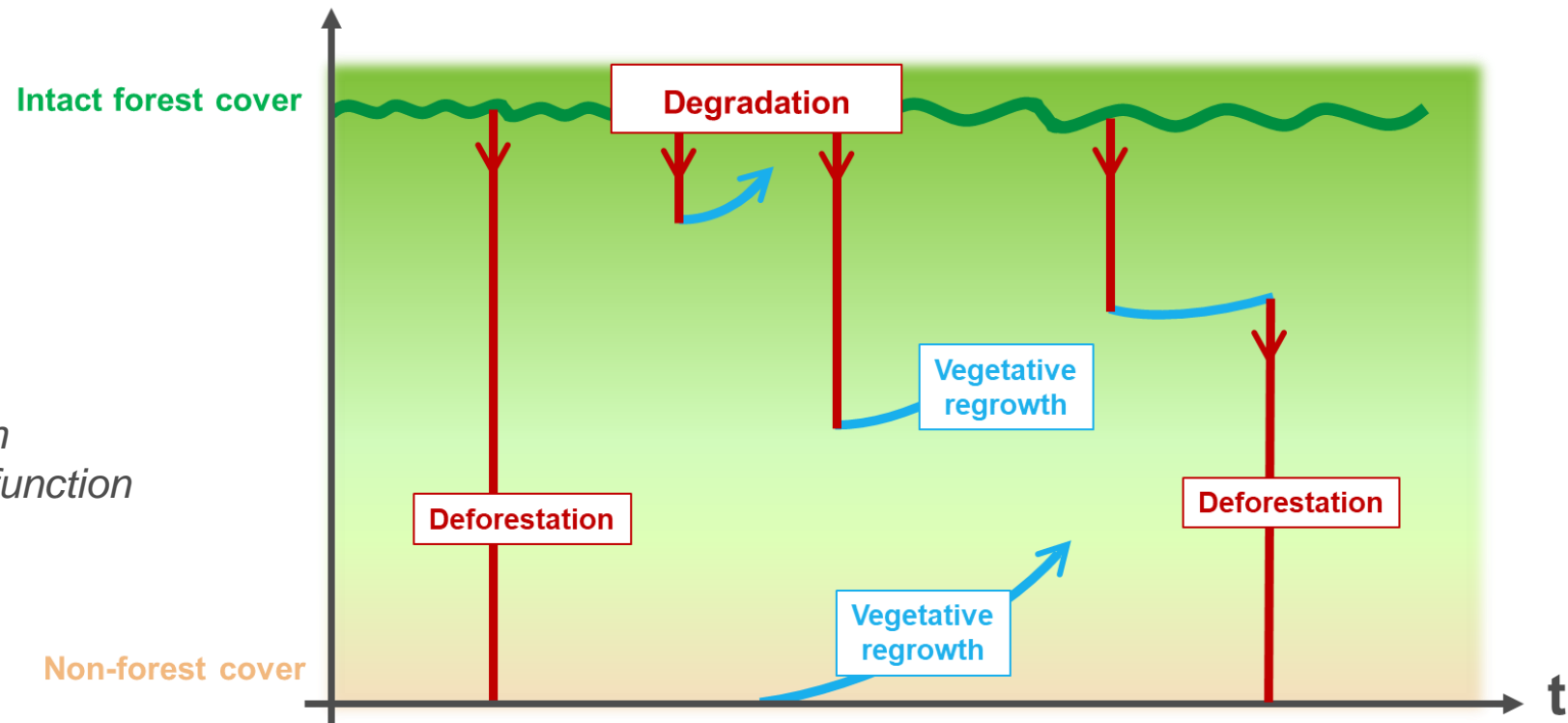
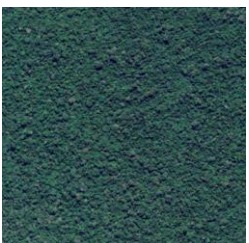
# Context

- Importance of tropical **deforestation** and forest **degradation** and their impacts on the provision of forest ecosystem goods and services

*Deforestation = conversion of forest to other land use*



*Degradation = changes within a forest which negatively affect its composition, structure, function*



# Context

- Need to **characterize** and **monitor** changes / transition stages of forest cover
- Implications to support global conservation policies and to accurately quantify forest disturbances contribution to global carbon fluxes

# Context

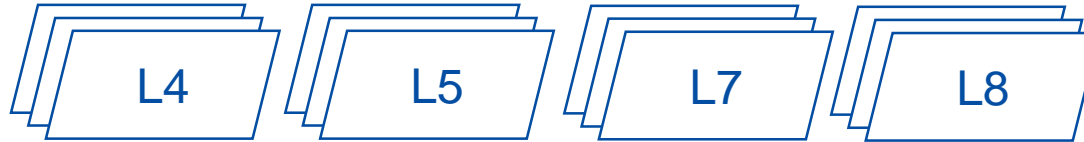
- Need to **characterize** and **monitor** changes / transition stages of forest cover
- Implications to support global conservation policies and to accurately quantify forest disturbances contribution to global carbon fluxes
- **Objective: map the status of tropical moist forest since 1990**
  - Covering the pantropical belt with a focus on evergreen forest
  - Based on a long and dense time series of Landsat images (30m) from 1982-2021

# Workflow fully integrated in GEE



## Landsat data (1982-2021)

*orthorectified top of  
atmosphere reflectance*



## Library of spectral signatures

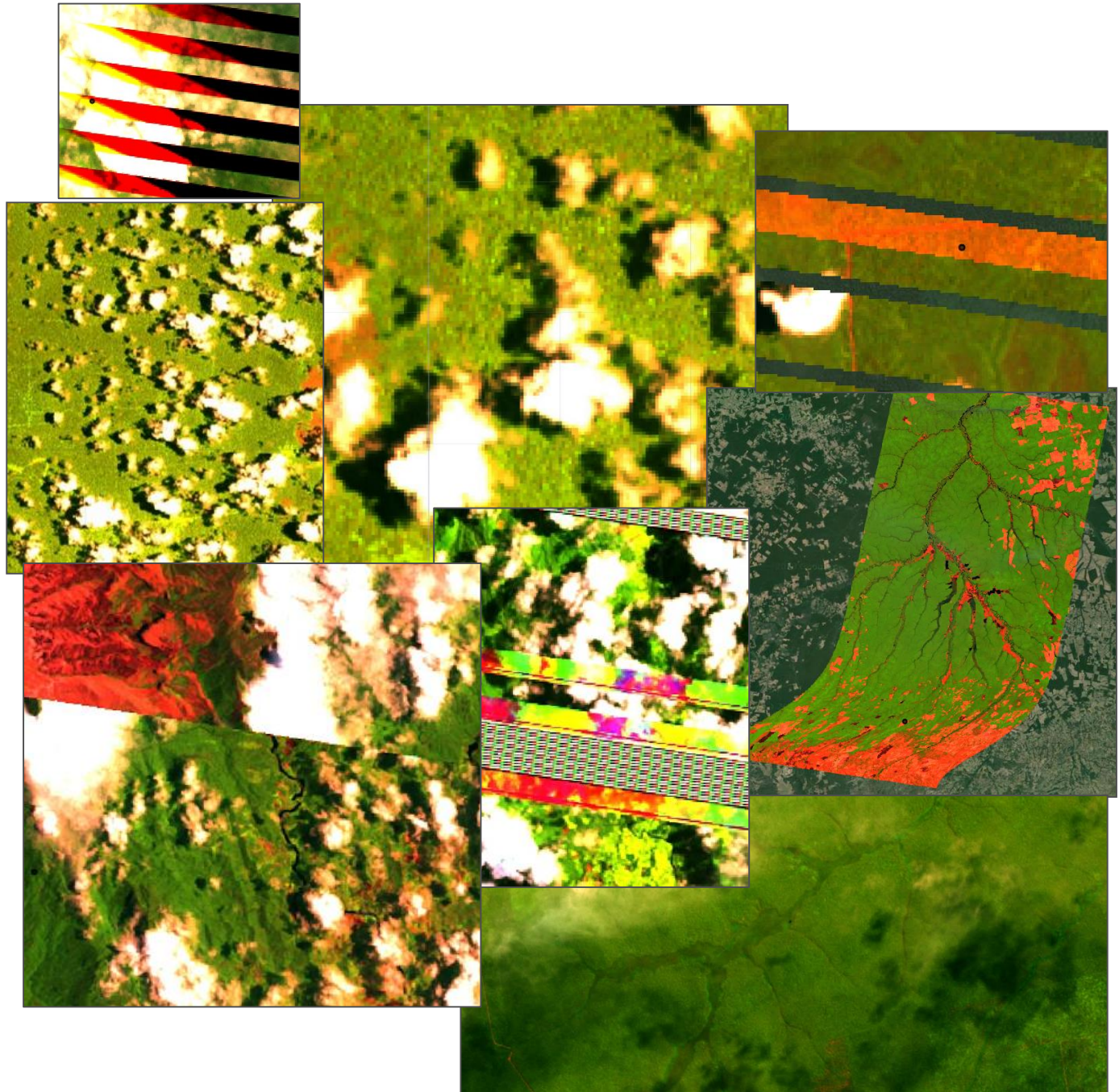
38,326 sampled pixels

*Bands, vegetation indices, HSV*



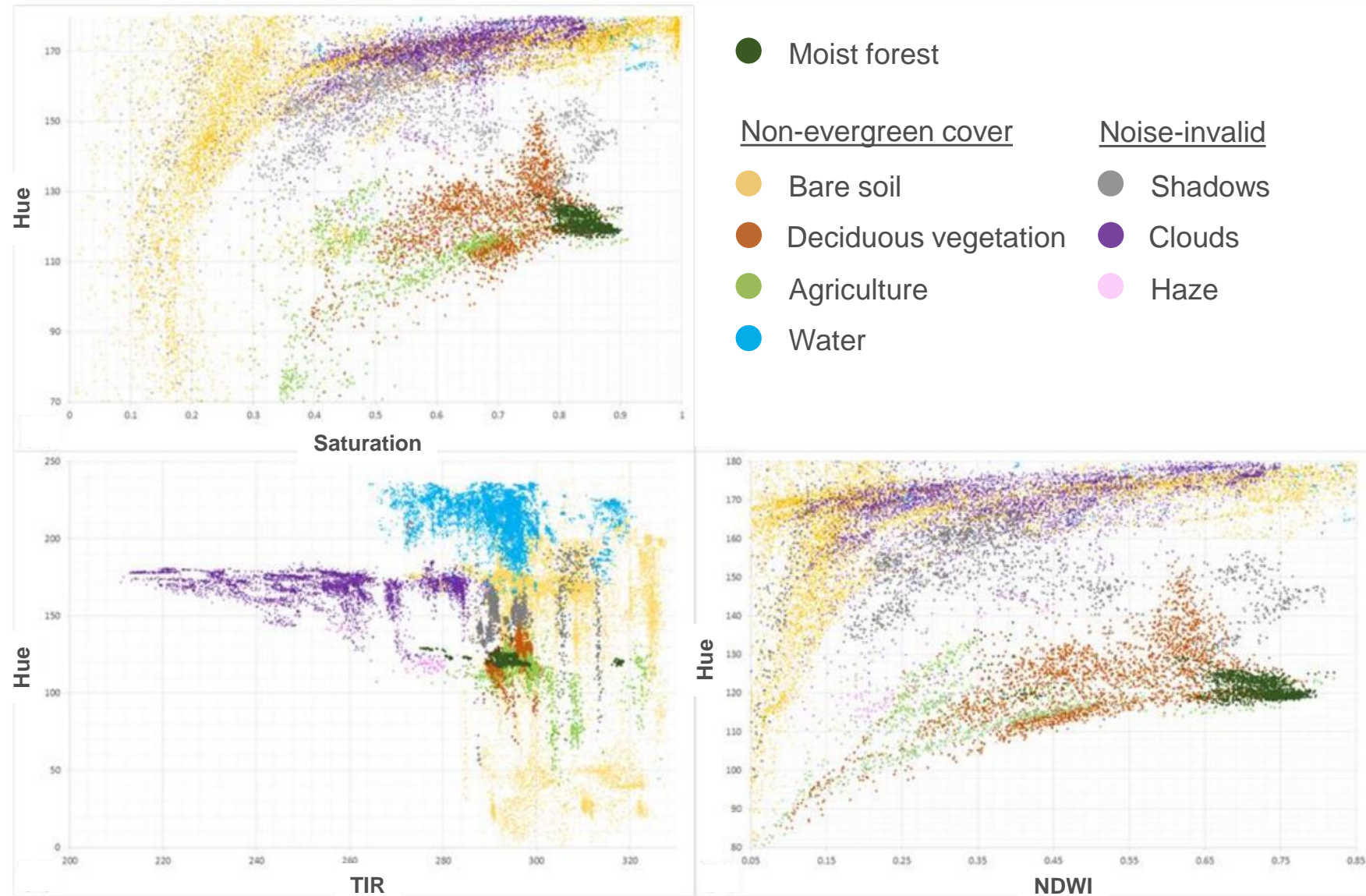
# Challenges

- Difficulty in processing large image sets ( $> 1$  million scenes)
- Complexity of masking clouds/shadows, haze, correcting sensor artefacts and sensor inaccuracies
- Complex detection of forest cover changes (esp. forest degradation or swidden agriculture)

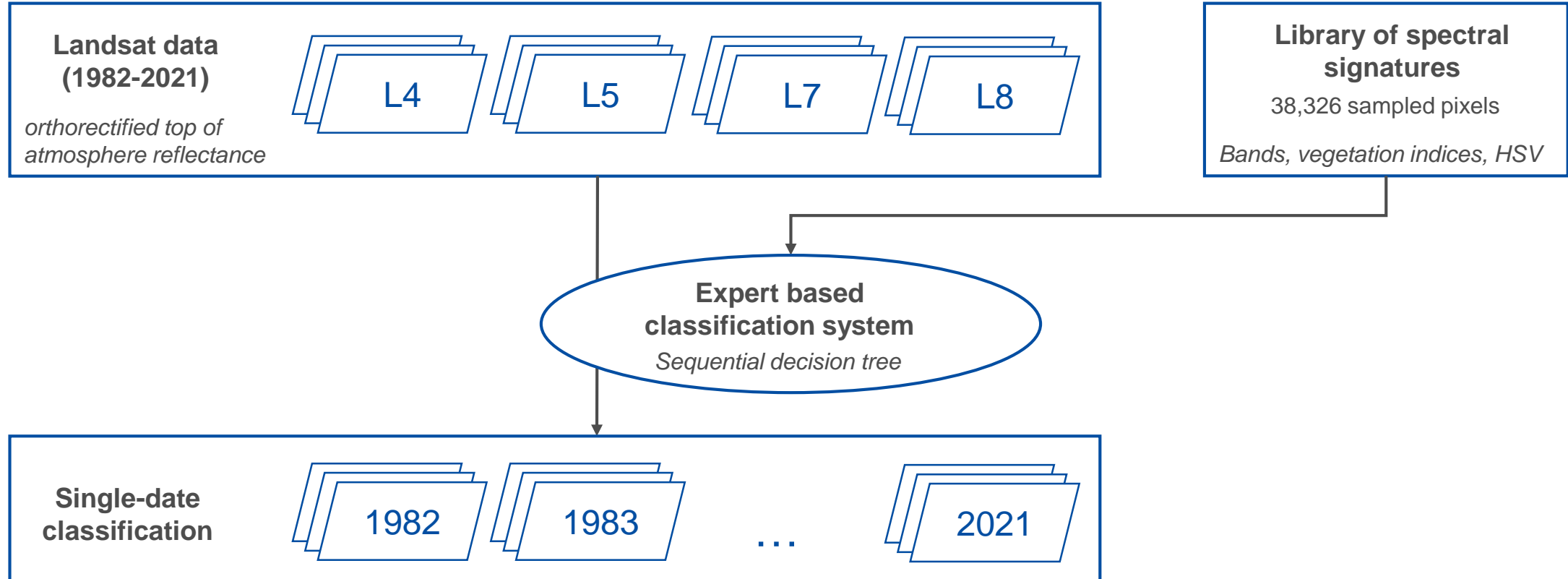




Requires a good understanding of the **multi-spectral signatures** of the various land cover types and noise



# Workflow fully integrated in GEE

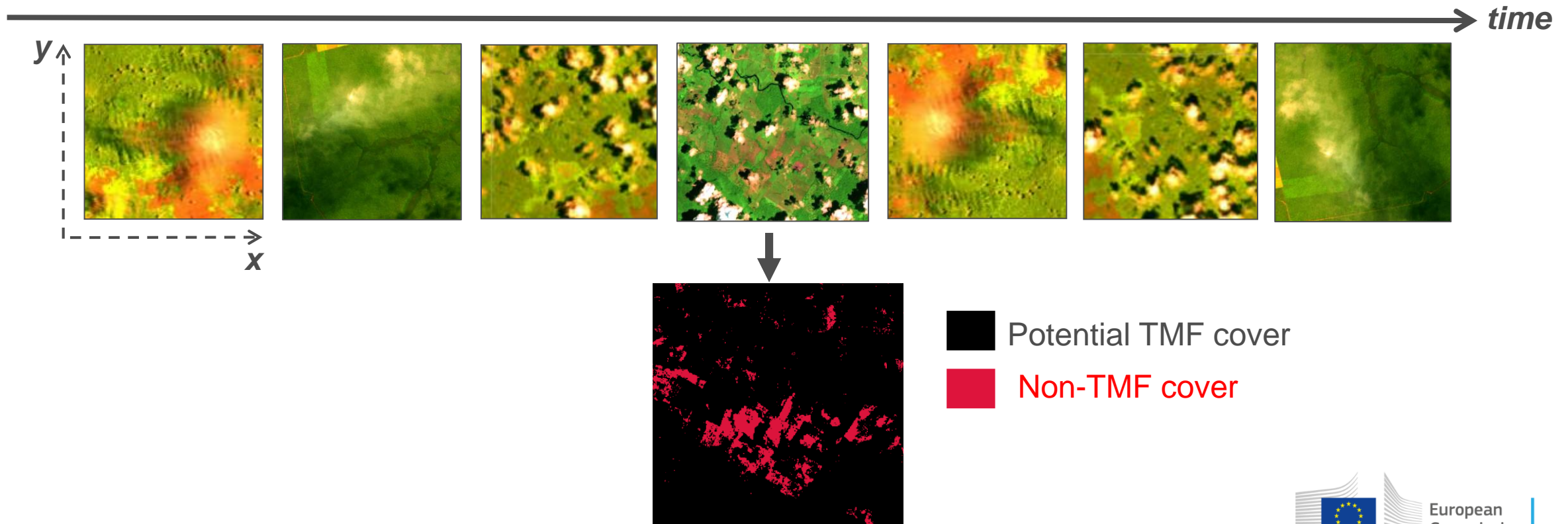




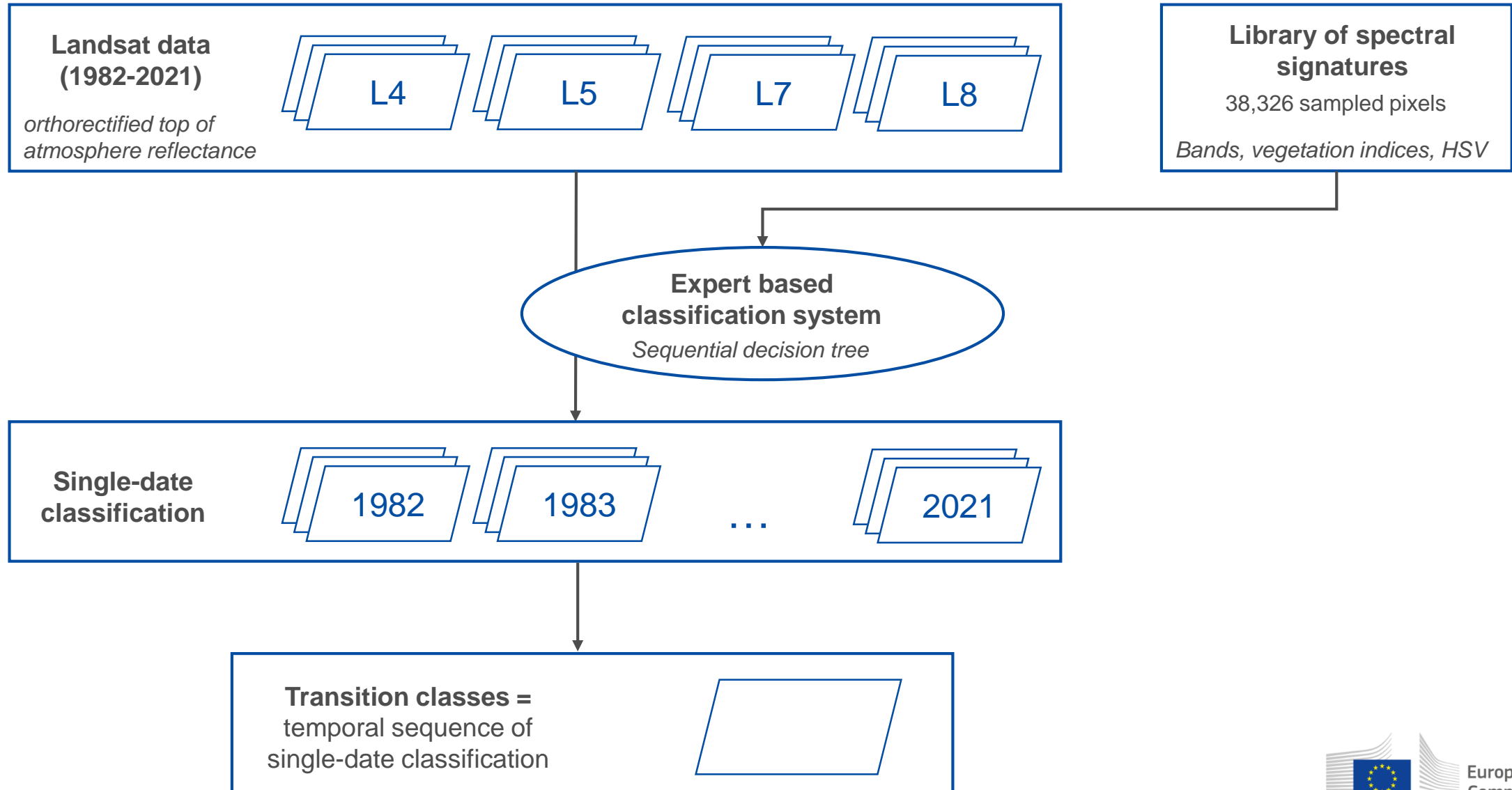
# Every single image of the 40 years Landsat archive is classified

Identify **non-valid** pixels (clouds, hazes, shadows ...)

Identify **valid** pixels → potential TMF cover + **non-TMF cover**



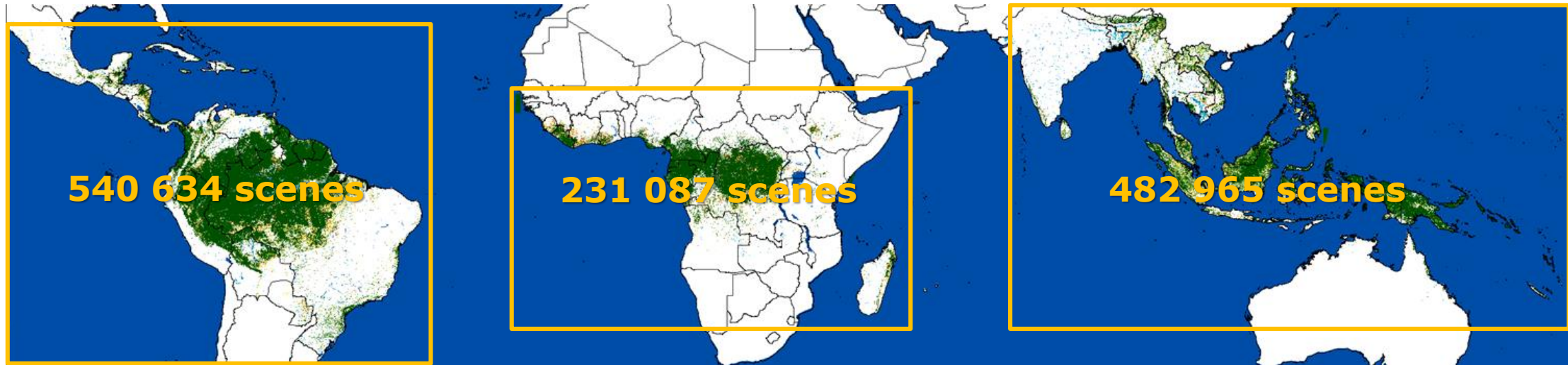
# Workflow fully integrated in GEE



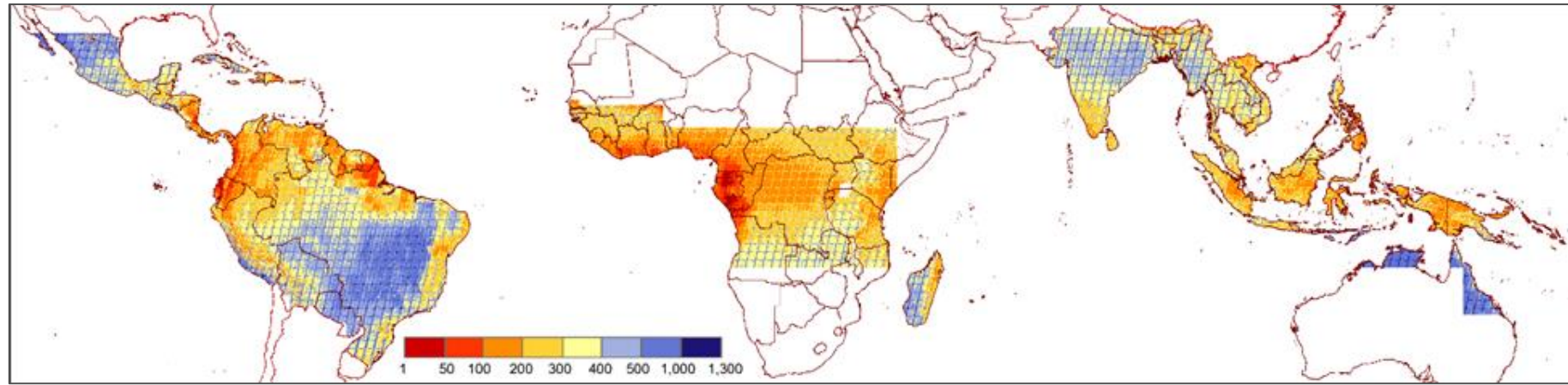
# Challenges

Full Landsat archive (L4, L5, L7 and L8) since 1982 presents large **geographical** and **temporal** unevenness

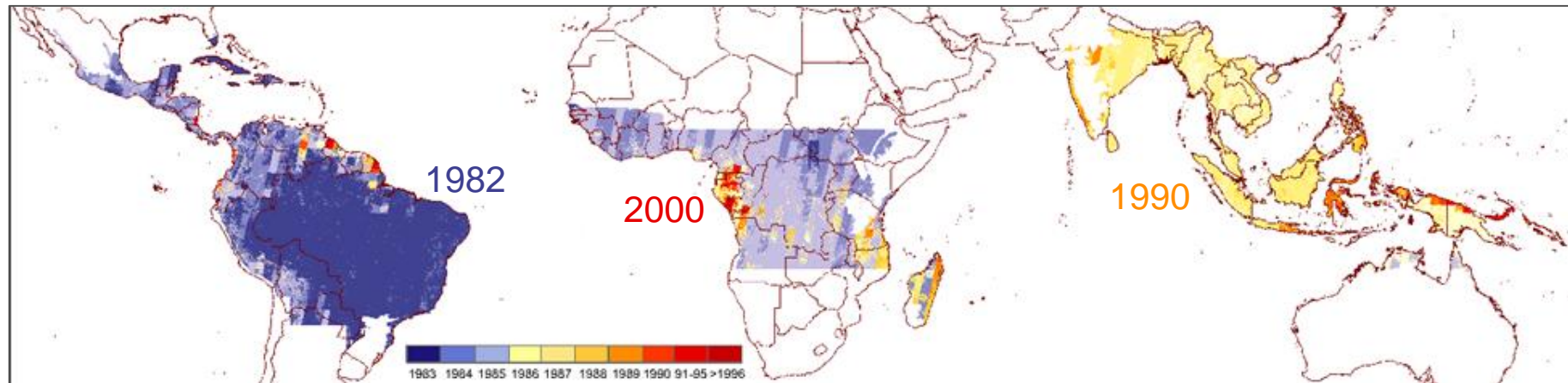
**Number of Landsat acquisitions  
(~1 250 000 scenes)**



## Total number of valid observations (1982-2019)



## First year with a valid observation



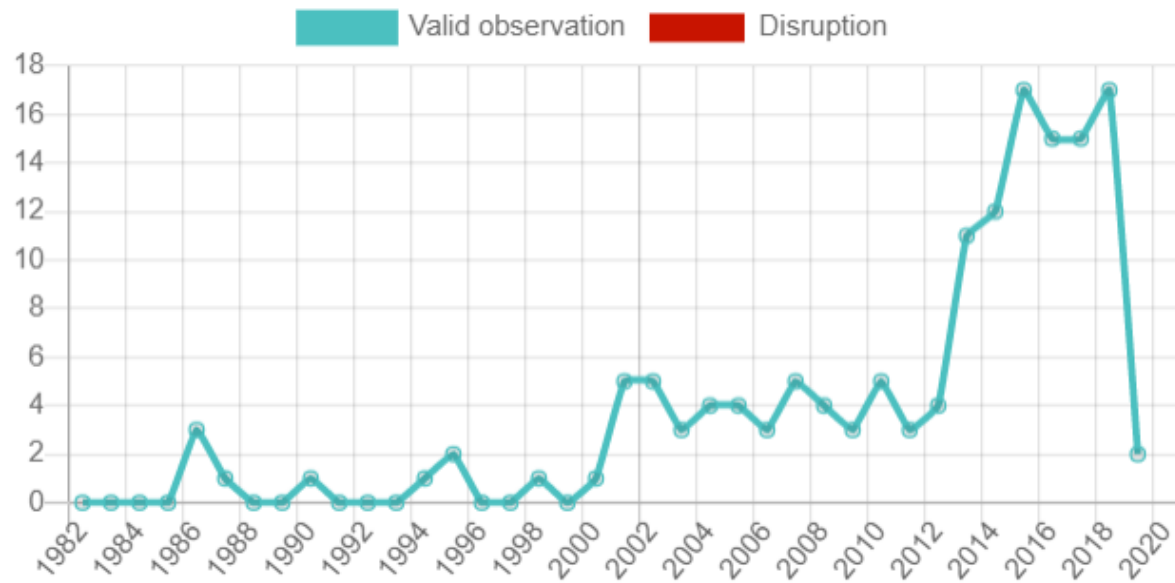
1982 1990 2002 2010 2021

**Baseline = TMF domain  
(5 years min)**

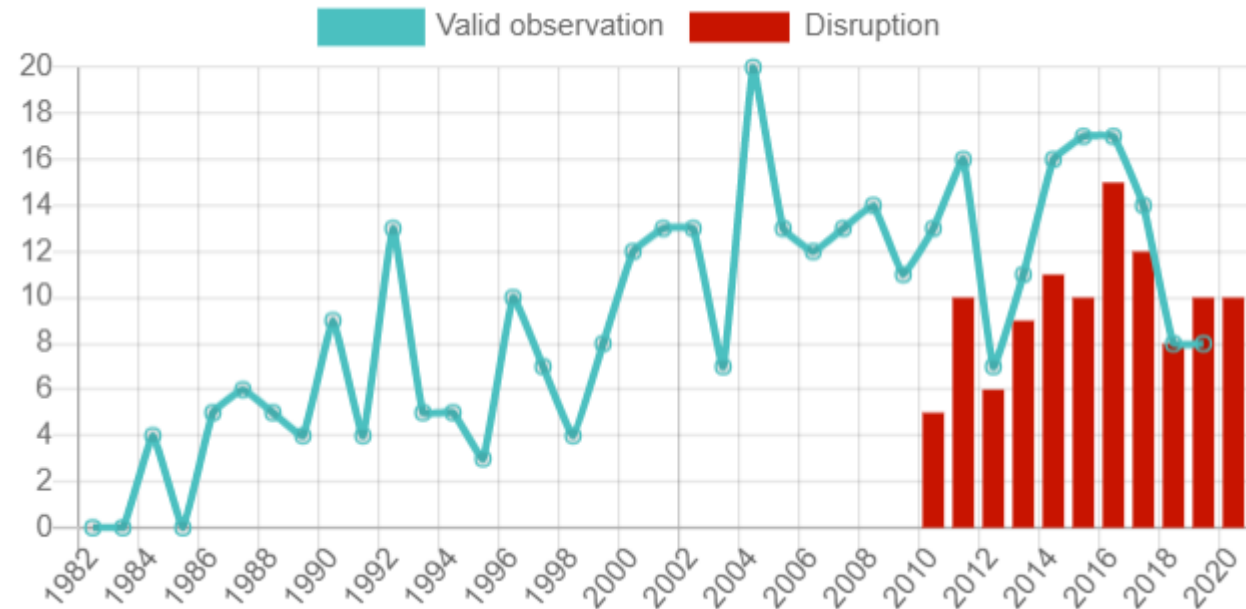
**Monitoring the changes within the TMF domain**

# Method

Temporal sequence of single-date classification (non-valid, TMF, non-TMF) at the pixel level



*No disturbances (non-TMF) detected*



*Canopy opening in 2010*

*Detection on non-TMF since then*



# Temporal sequence of single-date classification (non-valid, TMF, non-TMF)

Short degradation

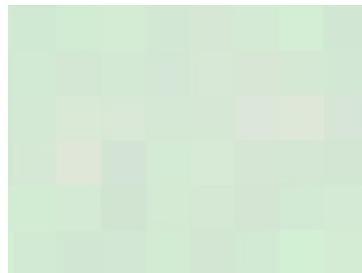
2015 - 04



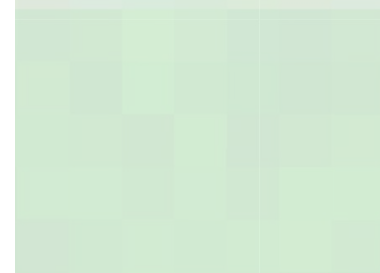
2015 - 07



2015 - 10



2015 - 12

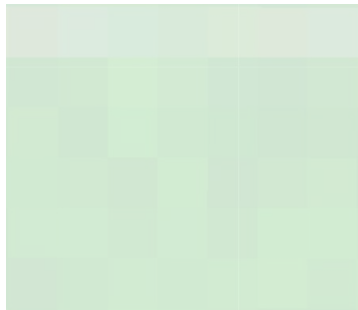


2016 - 02

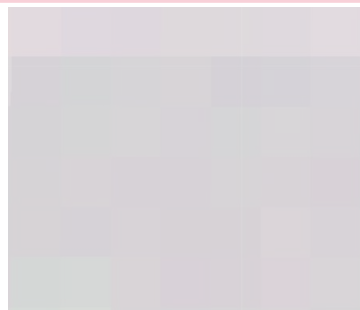


Long degradation

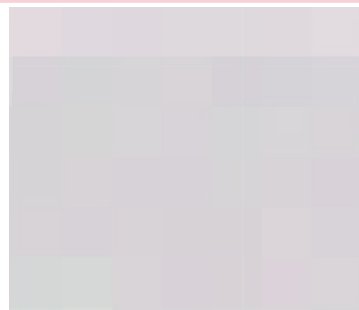
2015 - 06



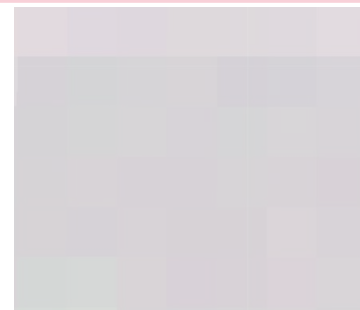
2015 - 08



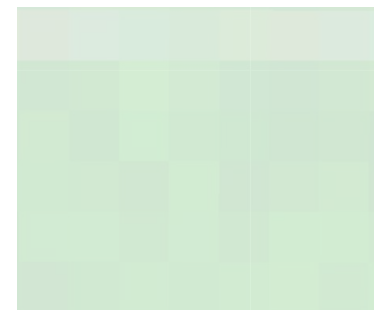
2016 - 03



2016 - 09



2016 - 11



Deforestation

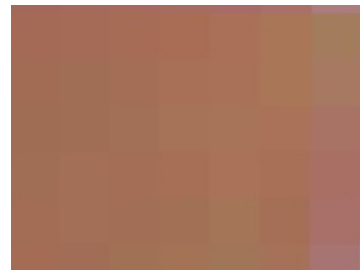
2017 - 05



2017 - 06



2017 - 11



2018 - 07

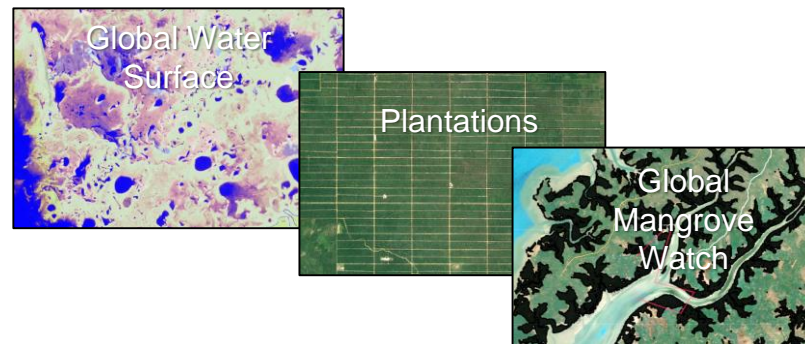
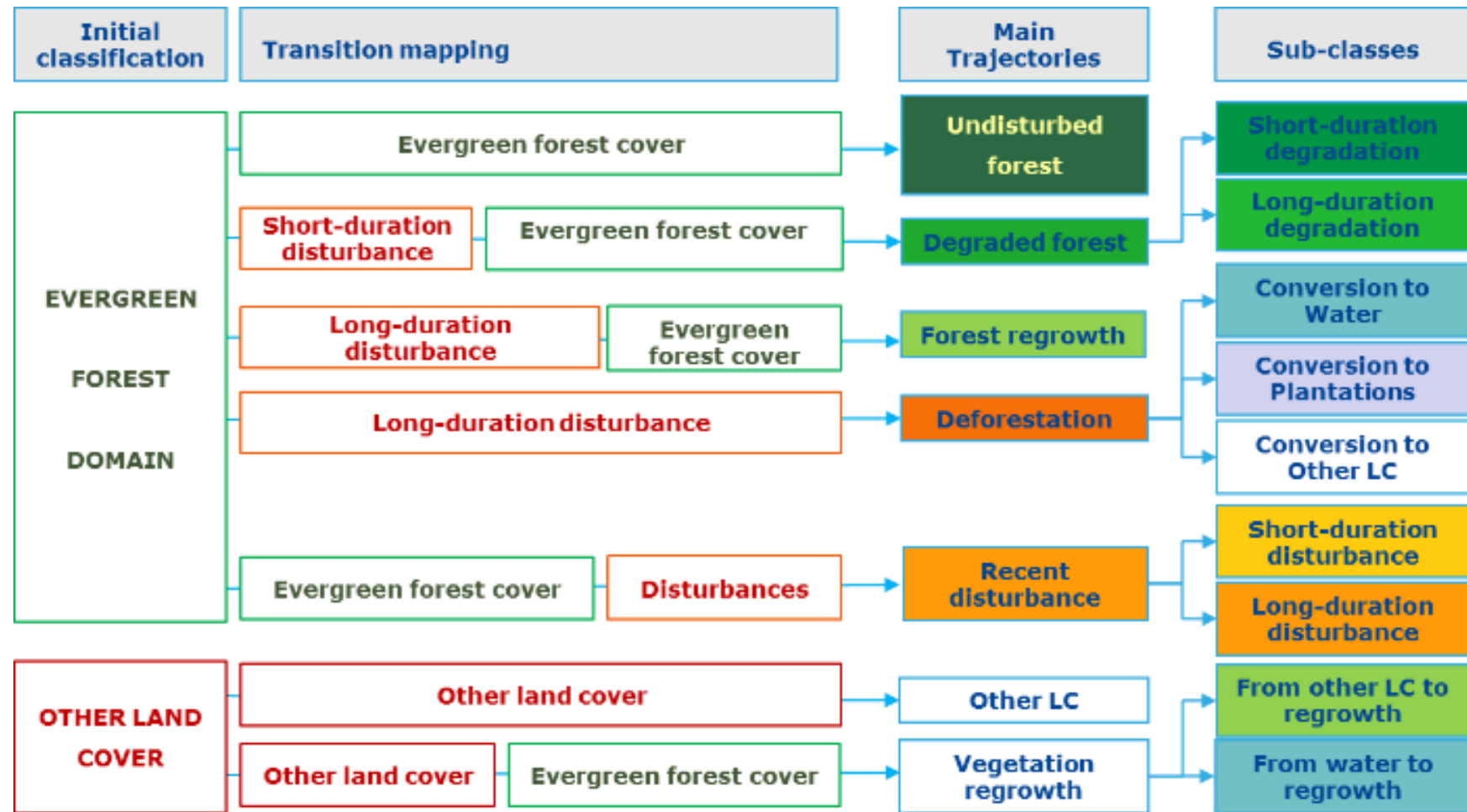


2019 - 07



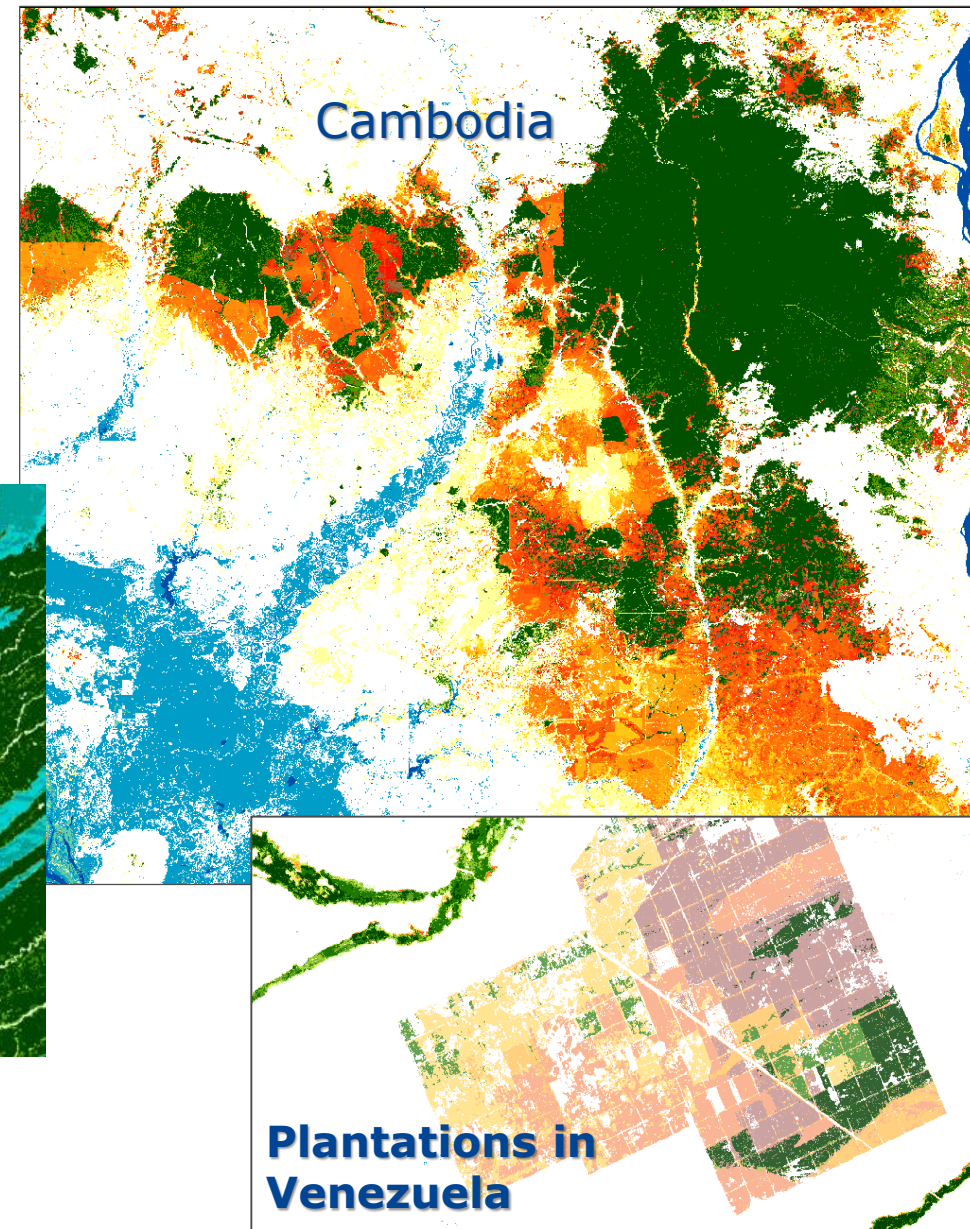
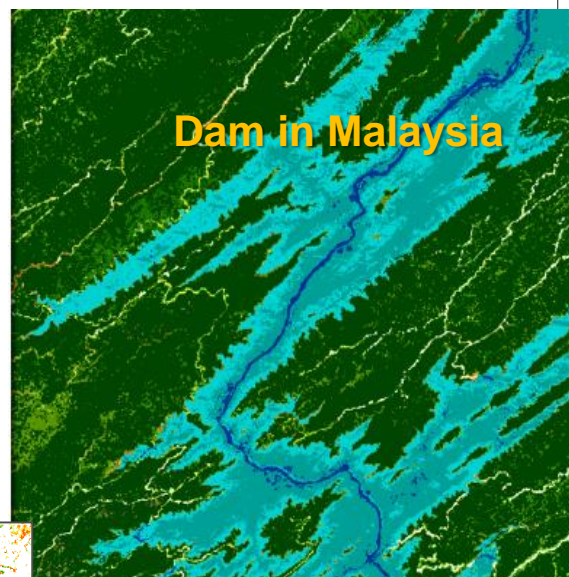
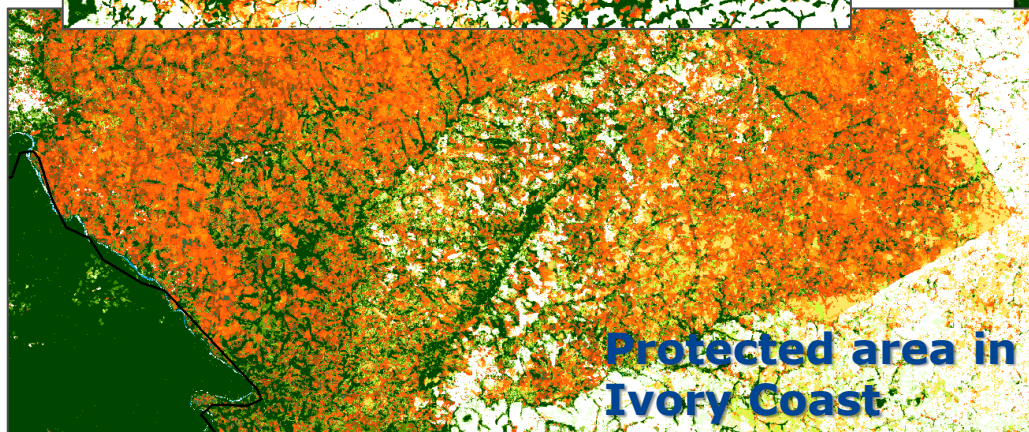
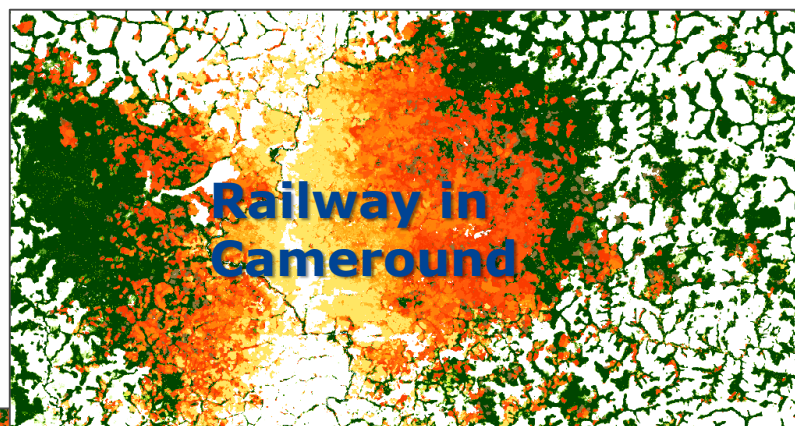
## Identification of sub-classes

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



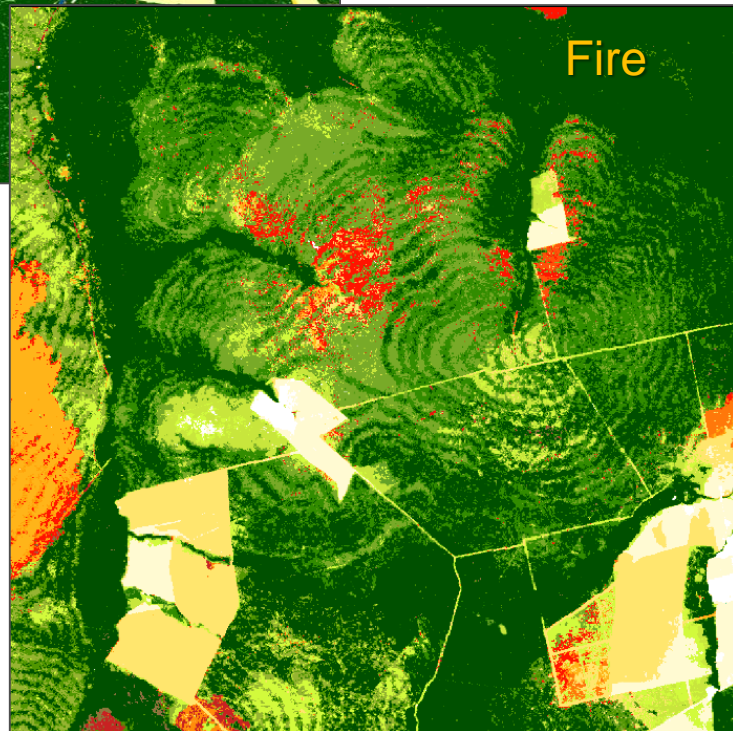
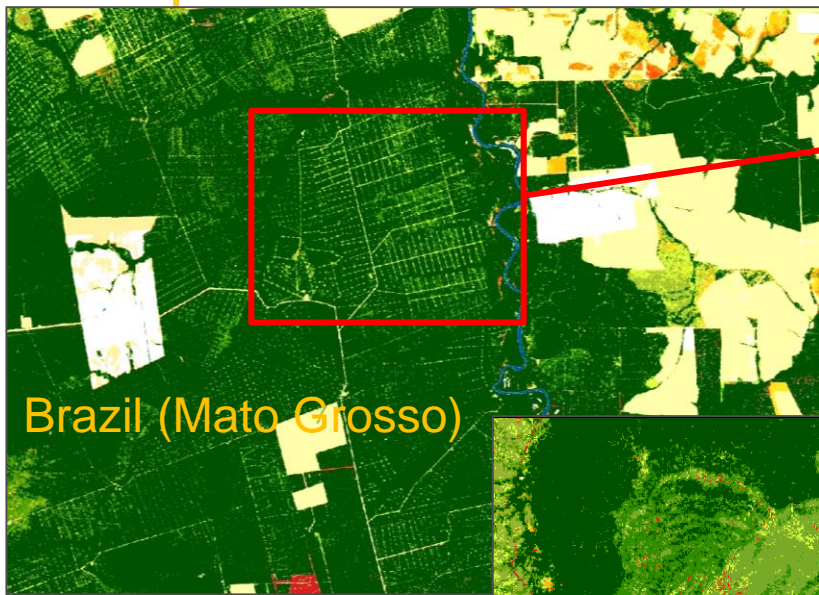


# Patterns of deforestation





# Patterns of degradation



16 km



3 km










Full dataset (1990-2020) at 30m available in GEE and through the TMF explorer for visualisation and download: <https://forobs.jrc.ec.europa.eu/TMF/>

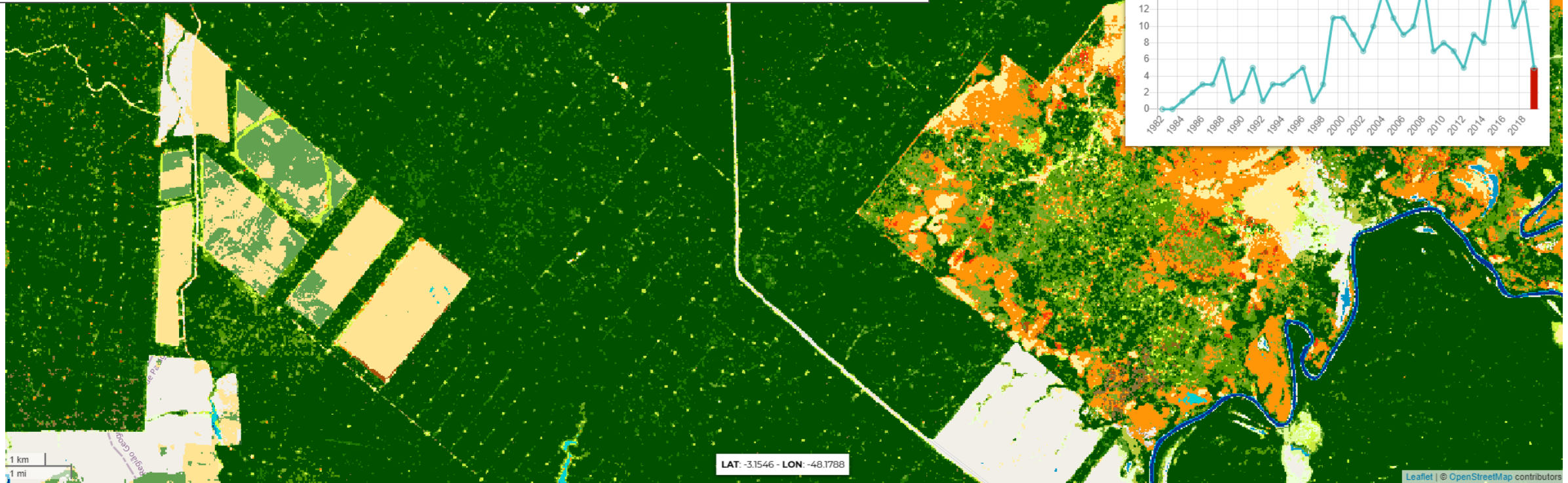
RESEARCH ARTICLE | ENVIRONMENTAL STUDIES

# Long-term (1990–2019) monitoring of forest cover changes in the humid tropics

 C. Vancutsem<sup>1,\*</sup>, F. Achard<sup>1</sup>,  J.-F. Pekel<sup>1</sup>,  G. Vieilledent<sup>1,2,3,4</sup>, S. Carboni<sup>5</sup>, D. Simonetti<sup>1</sup>,  J. Gallego<sup>1</sup>,  L. E. O....

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# Conclusions and perspectives

- TMF monitoring provide complete and detailed information on evergreen forest dynamics (by exploiting every valid pixel of the Landsat archive)
- Wall-to-wall maps of tropical evergreen forest cover dynamics at 30-meter resolution
  - Classification of change trajectories (regrowth, deforestation, degradation)
  - Extent of the tropical moist forest, remaining and disturbed for each year
  - Discrimination between deforestation and degradation
  - Characterization of disturbances by their timing, intensity and sequential dynamics
  - Identification of tree plantations & changes within the plantation areas, conversion to water
- The use of long time series & single-date image allows capturing more disturbances (logging and deforestation) and characterizing the transition stages
- **Perspectives:** the maps will be updated to future Landsat images and the methodology is currently being adapted to Sentinel-2

## ENVIRONMENTAL STUDIES

## Long-term (1990–2019) monitoring of forest cover changes in the humid tropics

C. Vancutsem<sup>1\*</sup>, F. Achard<sup>1</sup>, J.-F. Pekel<sup>1</sup>, G. Vieilledent<sup>1,2,3,4</sup>, S. Carboni<sup>2</sup>, D. Simonetti<sup>1</sup>, J. Gallego<sup>1</sup>, L. E. O. C. Aragão<sup>5</sup>, R. Nasi<sup>7</sup>

Accurate characterization of tropical moist forest changes is needed to support conservation policies and to quantify their contribution to global carbon fluxes more effectively. We document, at pantropical scale, the extent and changes (degradation, deforestation, and recovery) of these forests over the past three decades. We estimate that 17% of tropical moist forests have disappeared since 1990 with a remaining area of 1071 million hectares in 2019, from which 10% are degraded. Our study underlines the importance of the degradation process in these ecosystems, in particular, as a precursor of deforestation, and in the recent increase in tropical moist forest disturbances (natural and anthropogenic degradation or deforestation). Without a reduction of the present disturbance rates, undisturbed forests will disappear entirely in large tropical humid regions by 2050. Our study suggests that reinforcing actions are needed to prevent the initial degradation that leads to forest clearance in 45% of the cases.

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# Main results

- About **17% loss** of TMF since 1990 (~ **220 million ha**)
- Remaining forest area of 1088 million ha in 2020 of which **12%** is degraded
- **5.5 million ha** of deforestation and **6 million ha** of degradation, on average each year
- About **half** of the forests degraded annually are subsequently deforested.

