



# Monitoring of tropical moist forest deforestation and degradation with Sentinel 2

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Joint  
Research  
Centre

# Context and objectives

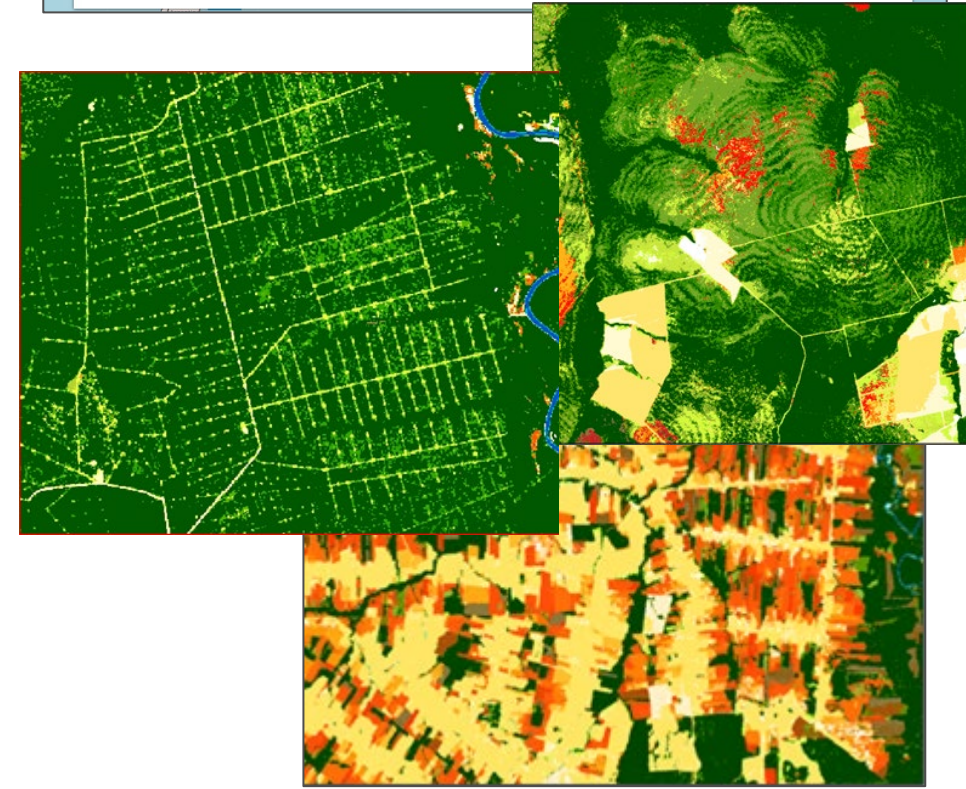
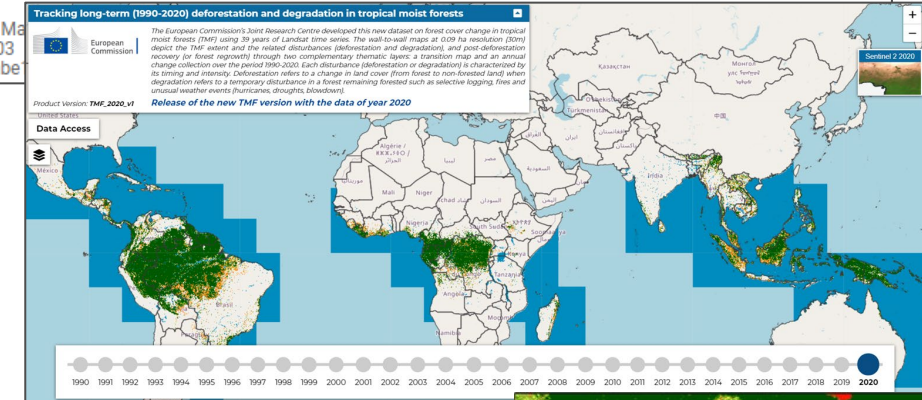
- TMF-Landsat Product : <https://forobs.jrc.ec.europa.eu/TMF/>
- **Adaptation of the TMF-Landsat approach to Sentinel-2 time series**
  - Single-date classification (expert system based on spectral-library)
  - Same transition rules (degradation, deforestation, regrowth)
  - Use of ancillary information on commodities and mangroves
- **Requires new developments**
  - Cloud-masking and quality control optimized for S2 over tropics
  - Single-date classification (expert system based on spectral-library)
- **Keeping two specific processing chains**
  - Landsat (1990-2022) and Sentinel-2 (2015-2022) chains
- **Combination of S2 and Landsat data to produce at 10m resolution**
  - Hybrid baseline map for the year 2017
  - Annual change maps from 2018 to 2022
  - Transition map for year 2022

## 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. ...

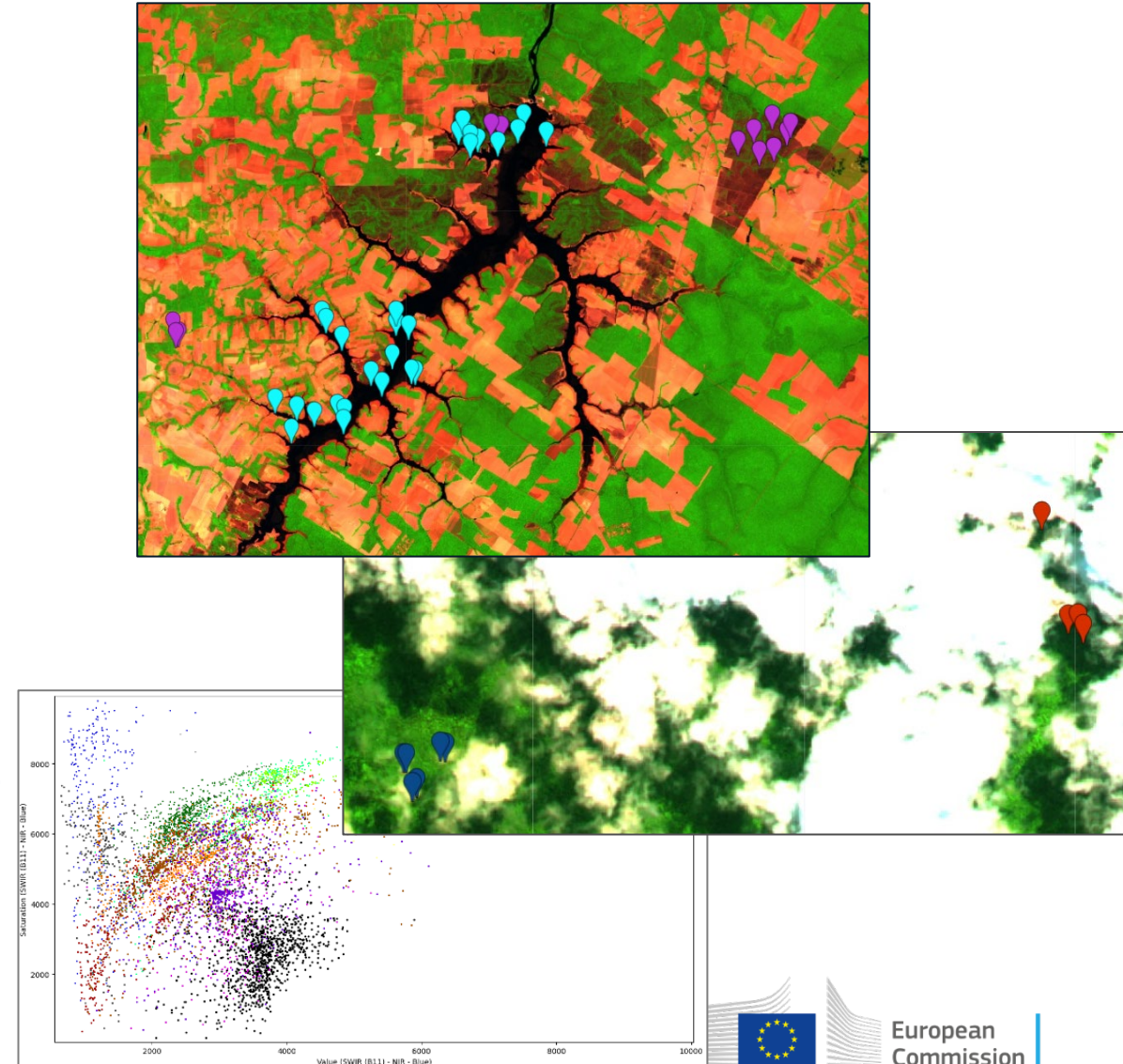
+ See all authors and affiliations

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# Adaptation to Sentinel-2 – Spectral library

- Cloud masking and single date classification steps are both based on a large spectral library
- **48,000 sample pixels were collected** through visual interpretation (2019-2021) to capture the spectral signatures of various LC types (forest, savanna, bare soils, urban areas, irrigated and non-irrigated cropland...), and atmosphere perturbations (clouds, hazes, cloud shadows) that are present at pan tropical scale
- The HSV (hue, saturation, and value) transformation of the spectral bands (SWIR2-NIR-Red, & SWIR1-NIR-Blue) and vegetation indices (NDWI, NDVI, NDVIre, NBR, BSI) are computed to complement the spectral signatures





# Adaptation to Sentinel-2 - Cloud mask

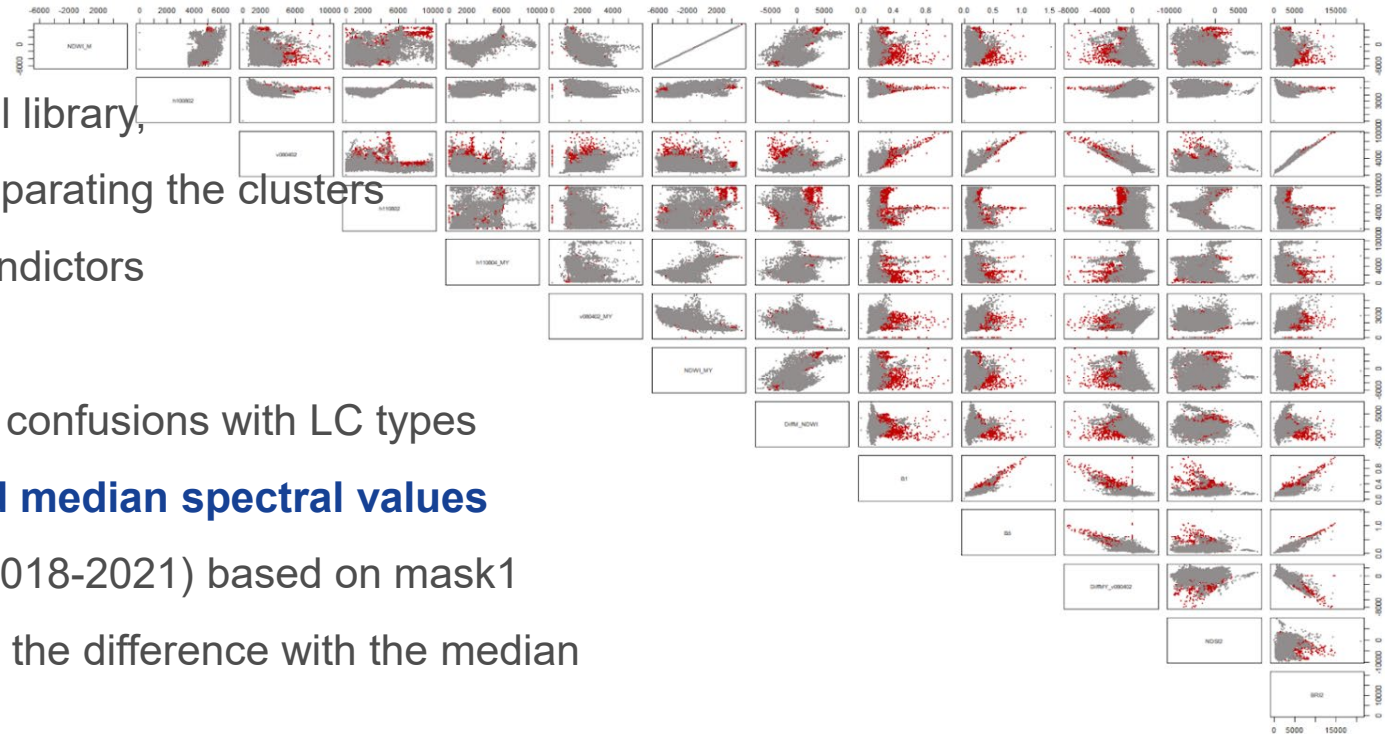
## 1. Based on single date spectral values

- Separability analysis: based on the spectral library, identification of the best indicators for separating the clusters
- Delineation of the cluster hulls for a set of indicators
- Application on single-date images
- Quality check and identification of possible confusions with LC types

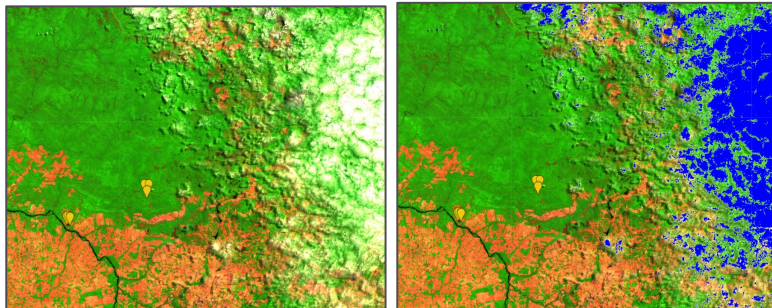
Iterative process

## 2. Based on difference between single date and median spectral values

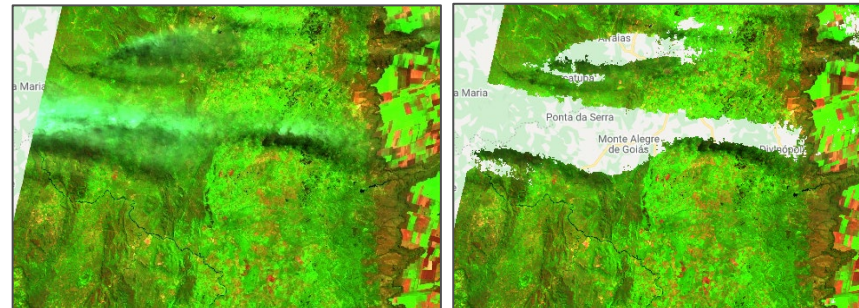
- Computation of the median over 4 years (2018-2021) based on mask1
- Refinement of the cloud masking based on the difference with the median



### • Clouds

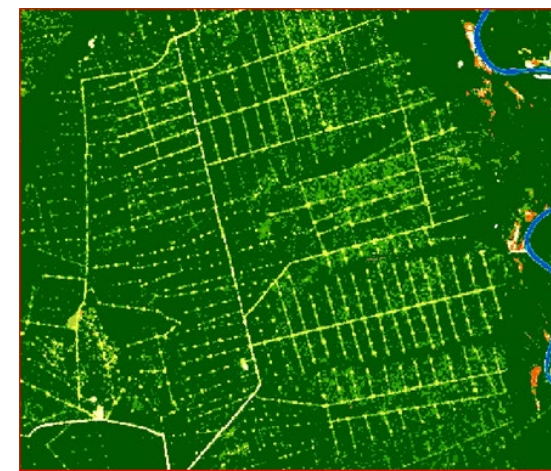


### • Cirrus



### • Cloud shadows

# Adaptation to S2 - Mapping approach

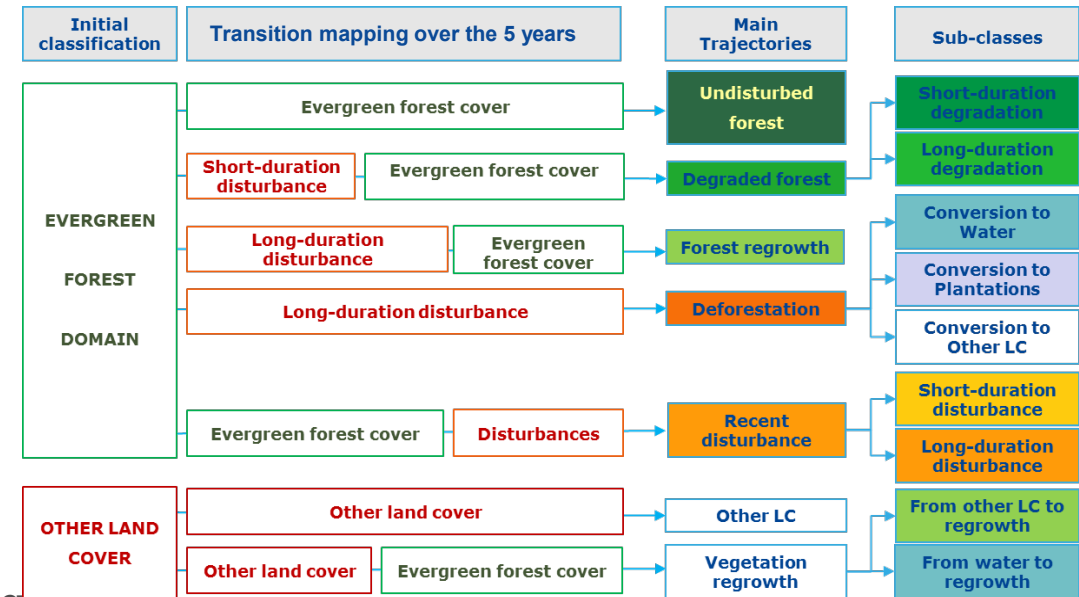


## Single-date classification

- Based on the spectral library – supervised classification
- Two spectral classes of disruption observations: high and low confidence
- Allows capturing short-duration events (logging) and characterizing disturbances (timing and intensity)

## Temporal classification:

- Based on the sequence of single-date classifications
- **Hybrid baseline:** end of year 2017, combining with historical information from Landsat (1990-2017)
  - **Undisturbed forest (incl. mangroves)**
  - **Degraded forest**
  - **Forest regrowth**
  - Deforested areas (inc. plantations)
  - Water
  - Other Land cover
- Identification of change trajectories (2018-2022)
- Combination with the mask of tree commodity and mangroves



- Production of annual change maps (forest extent and disturbances) at 10m

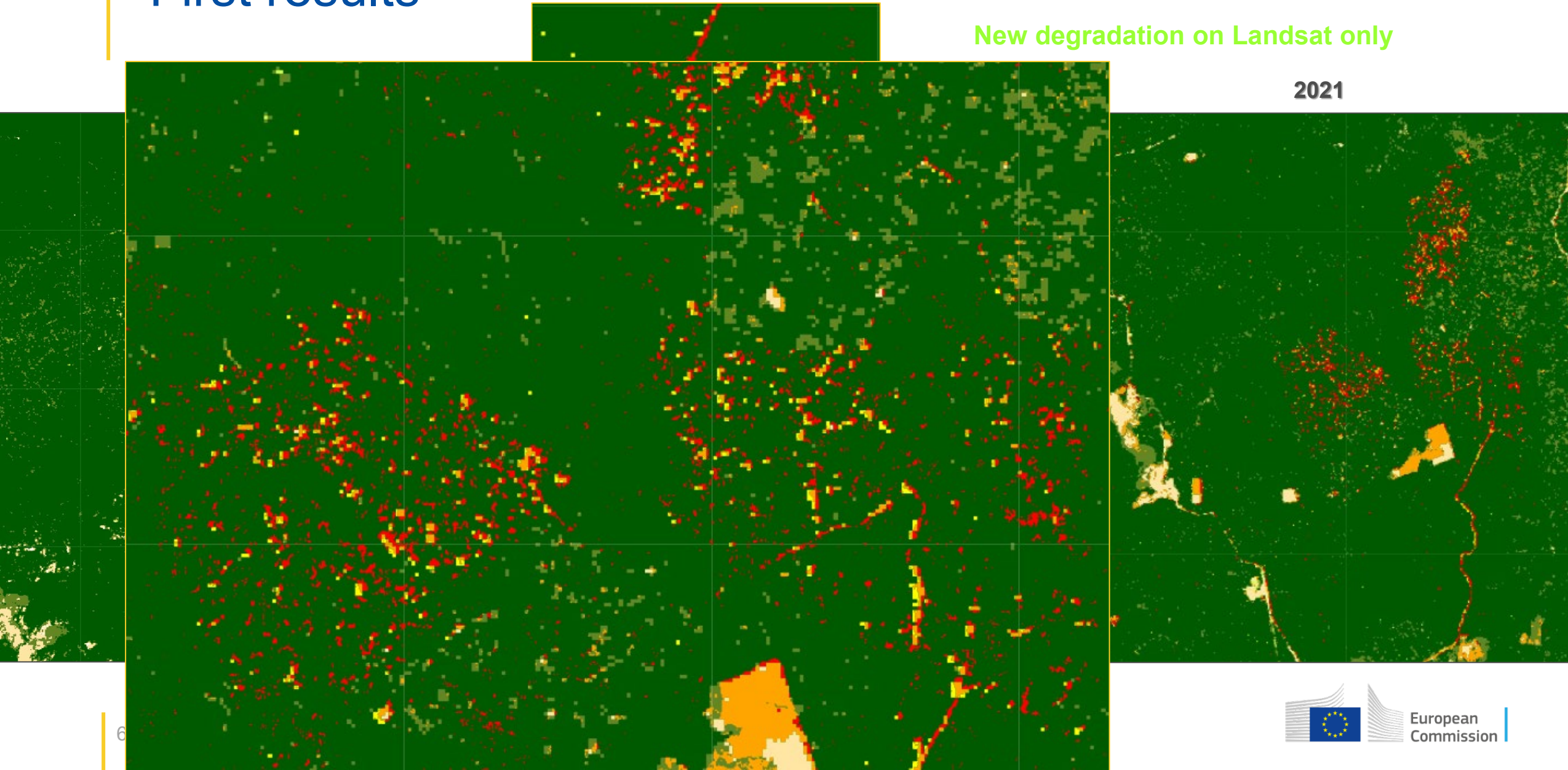


# First results

New degradation on S2 only

New degradation on Landsat only

2021



# First results

- More degraded areas captured with S2 at 10m (missed with Landsat) – to be better quantified
  - × 4 more valid pixels for year 2021 compared to Landsat (L7 and L8 combined)
- Refinement of the disturbance edges and linear disturbances (rivers, logging roads,...)
- Spatial shift between Landsat and S2
  - We will combine both data sources in the baseline and provide the source as metadata
  - We will consider only the S2 detections for the changes from year 2018

# Validation and accuracy assessment

Transition map	Reference		
	Undisturbed	Forest Change	Area on the map
Undisturbed	898.64	65.76	964.40
Forest Change	27.38	297.82	325.20
Area cor (Mha)	926.02	363.58	1289.60
Producer Accuracy	97.0%	81.9%	
User Accuracy	93.2%	91.6%	
Commission error (Mha)	65.8	27.4	
Omission error (Mha)	27.4	65.8	
Difference (Mha)	-38.4	38.4	
CI (95%)	14.8	14.8	

## Objectives:

Quantification of uncertainties of S-2 based classifications

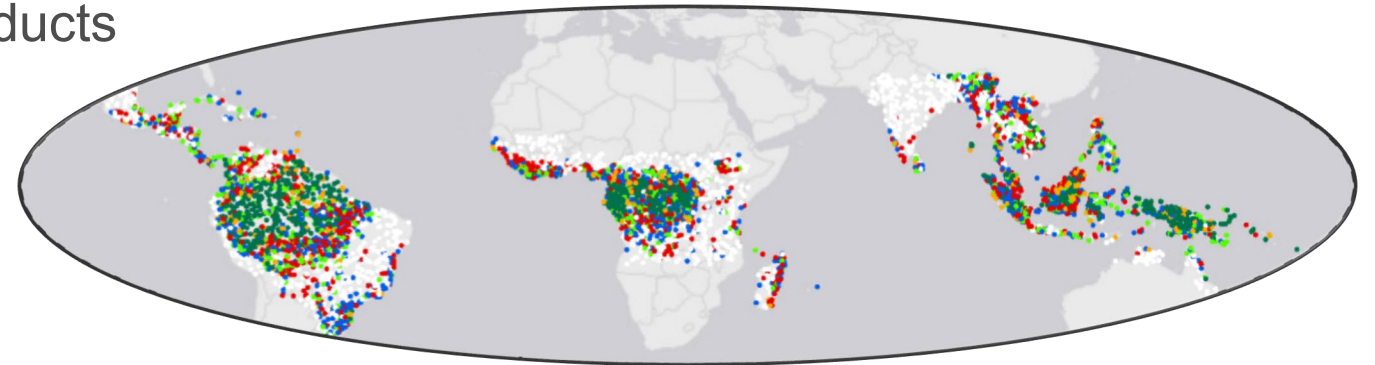
Comparison between Landsat and S-2 products

## Sampling design:

Random stratified sampling of 6000 plots

Accuracy of TMF-Landsat transition map from a reference sample with weighted matrix and error estimates (million ha)

Source: Vancutsem et al, Science Advances, 2021



Undisturbed forest  
Forest degradation

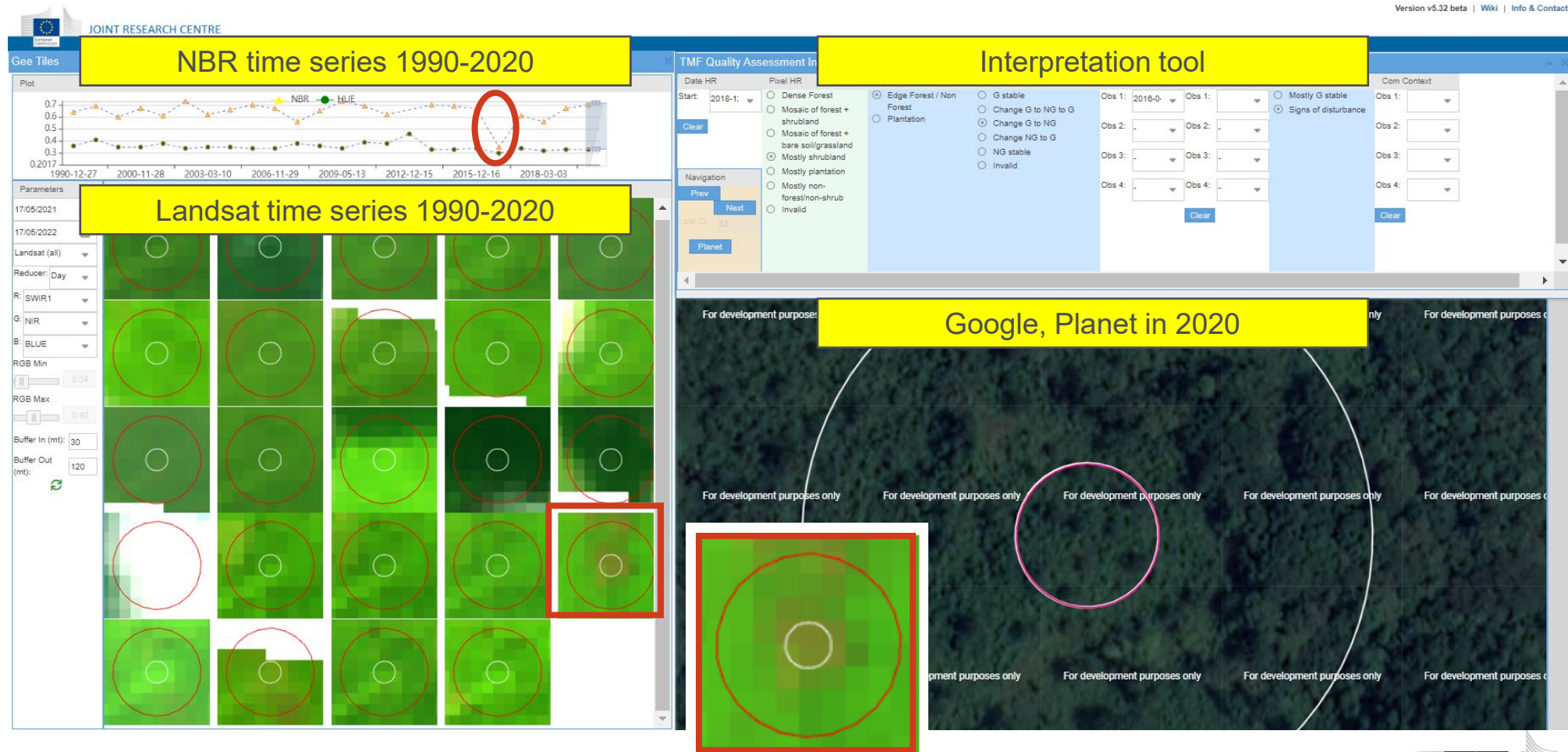
Deforestation  
Regrowth



# Validation and accuracy assessment

## Response design:

Multi-source visual interpretation (Google/Bing HR, Planet basemaps in 2020, Landsat time series) considering pixel and context levels



# Conclusions and next steps

- TMF-Landsat approach is applied to S2 data
  - Faster development (compared to Landsat)
  - Advantages for users : same classes, easy to use and interpret
- Adaptations to S2 imagery
  - Rigorous cloud masking on tropical areas is needed (challenging without TIR)
  - Processing at 10m requires much more memory, space and computing-time
  - Identification of new disturbances and finer edges
- Maintaining the Landsat TMF products at 30m
  - To ensure temporal consistency for trends analysis before year 2015
  - Higher confidence when both sensors (landsat and S2) are identifying a disturbance
  - Differences between the two maps (10m and 30m) have to be quantified
- Production of hybrid baseline (2017), annual change (2018-) and transition maps at 10m
  - S2 TMF chain benefits from TMF Landsat historical classes
  - First products on South America expected by end of 2022



# Proposal for a EU regulation on Deforestation-free products

Brussels, 17.11.2021  
COM(2021) 706 final

2021/0366 (COD)

Proposal for a

## REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on the making available on the Union market as well as export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010

### Article 1

#### Subject matter and scope

This Regulation lays down rules regarding the placing and making available on the Union market, as well as the export from the Union market, of cattle, cocoa, coffee, oil palm, soya and wood (“relevant commodities”) and products, as listed in Annex I, that contain, have been fed with or have been made using relevant commodities (“relevant products”), with a view to

- (a) minimising the Union’s contribution to deforestation and forest degradation worldwide
- (b) reducing the European Union’s contribution to greenhouse gas emissions and global biodiversity loss.

**Biodiversity:**  
deforestation-free products on the EU market

17 November 2021  
#EUGreenDeal

*“Trees and forests are true allies in the fight against the climate and biodiversity crises. Trees purify our air, cool our cities, and take up CO2. We need to be their allies too. Our deforestation regulation answers citizens’ calls to minimize the European contribution to deforestation and to promote sustainable consumption.”*

Frans **Timmermans**, Executive Vice-President for the European Green Deal

*“We must protect biodiversity and fight climate change not only in the EU, but globally, and our consumption should not contribute to global deforestation which is a major cause of biodiversity loss and greenhouse gas emissions. Thus we present the most ambitious legislative measure ever put forward by any country anywhere in the world to curb deforestation and forest degradation and to help us tackle the twin crises of global warming and biodiversity loss.”*

Virginijus **Sinkevičius**, Commissioner for the Environment, Oceans and Fisheries

Consumption of beef, palm oil, soy beans, wood, cocoa and coffee in the European Union drives deforestation and forest degradation across the world. The European Union aims to stop this by no longer allowing deforestation-related commodities and products on the market.

European citizens supported EU action to tackle deforestation and forest degradation with **1.2 million responses** to a public consultation.

Deforestation and forest degradation are important drivers of global warming and biodiversity loss. **23% of greenhouse gas emissions** come from agriculture, forestry and other land uses.

[https://ec.europa.eu/environment/publications/proposal-regulation-deforestation-free-products\\_en](https://ec.europa.eu/environment/publications/proposal-regulation-deforestation-free-products_en)



# Forthcoming Copernicus Tender for Global Land and Forest Monitoring

OJ/S S95

17/05/2022

261150-2022-EN

1 / 2

This notice in TED website: <https://ted.europa.eu/udl?uri=TED:NOTICE:261150-2022:TEXT:EN:HTML>

**Belgium-Brussels: Copernicus Land and Forest Mapping and Monitoring  
2022/S 095-261150**

**Prior information notice**

**This notice is for prior information only**

**Services**

**The Copernicus Global Land service will procure** a dynamic global land surface characterisation, **global annual land cover mapping and tropical forest monitoring products at 10 m resolution**. The procurement will ensure the continuity of the production of the Global Land Cover map collection, the provision of a continuous dynamic generation of land surface and cover characteristics on sub-annual and annual basis and the development and implementation of a tropical forest monitoring component.

Available at: <https://etendering.ted.europa.eu/cft/cft-display.html?cftId=11019>