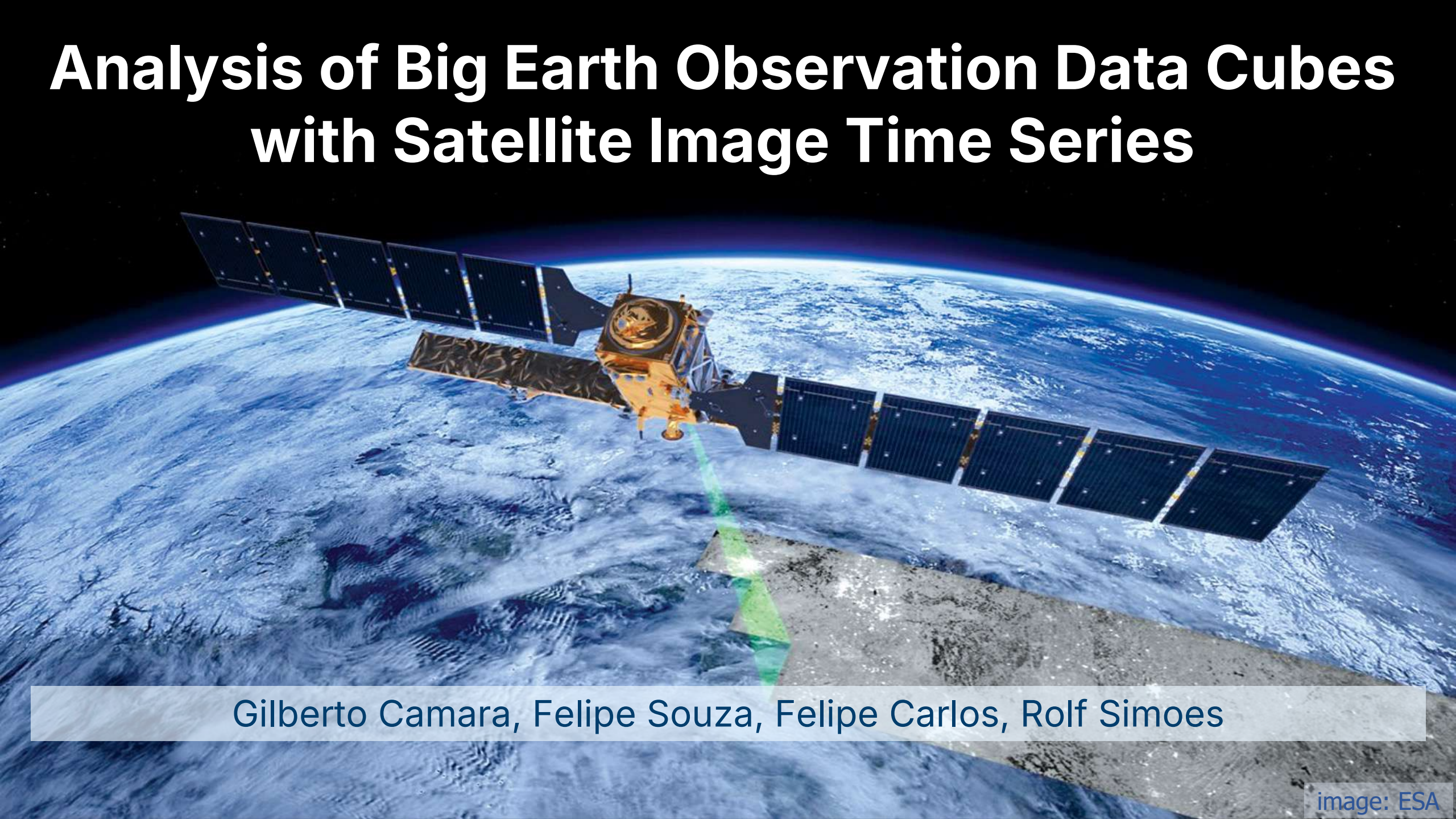
Analysis of Big Earth Observation Data Cubes with Satellite Image Time Series

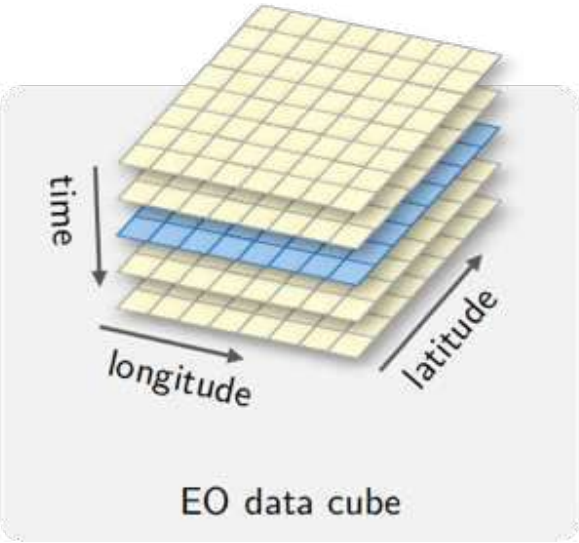


Gilberto Camara, Felipe Souza, Felipe Carlos, Rolf Simoes

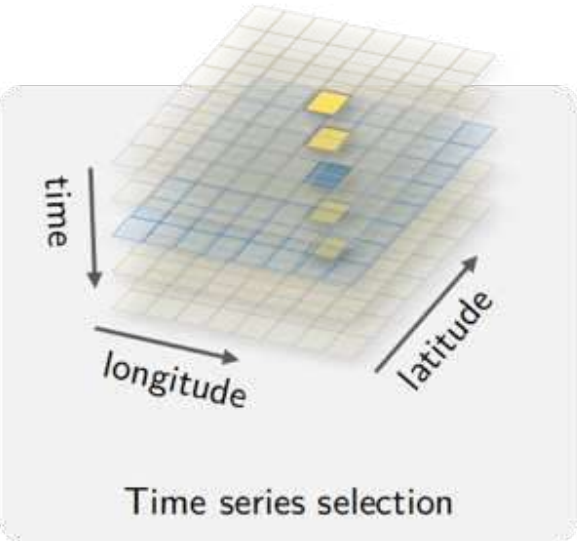
image: ESA

What is an EO data cube?

EO image collection



EO data cube



Time series selection

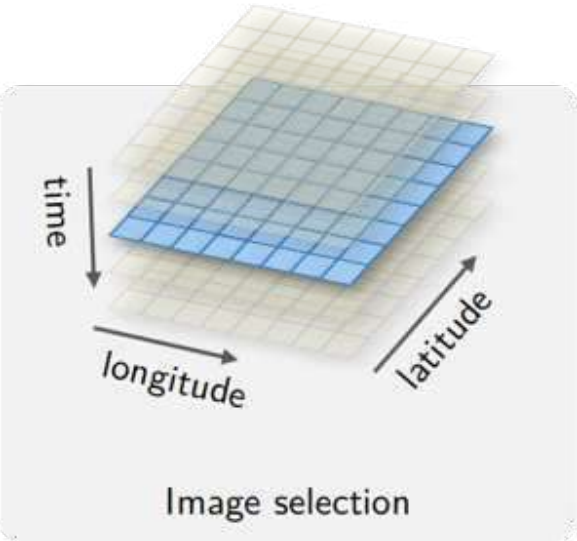
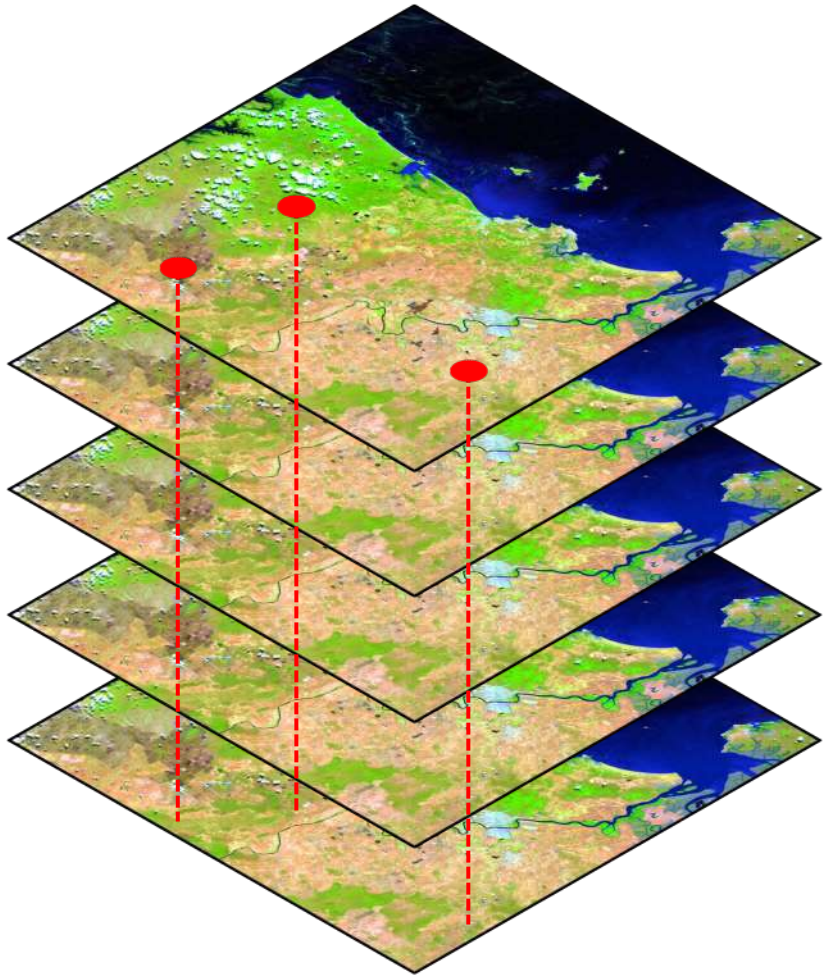
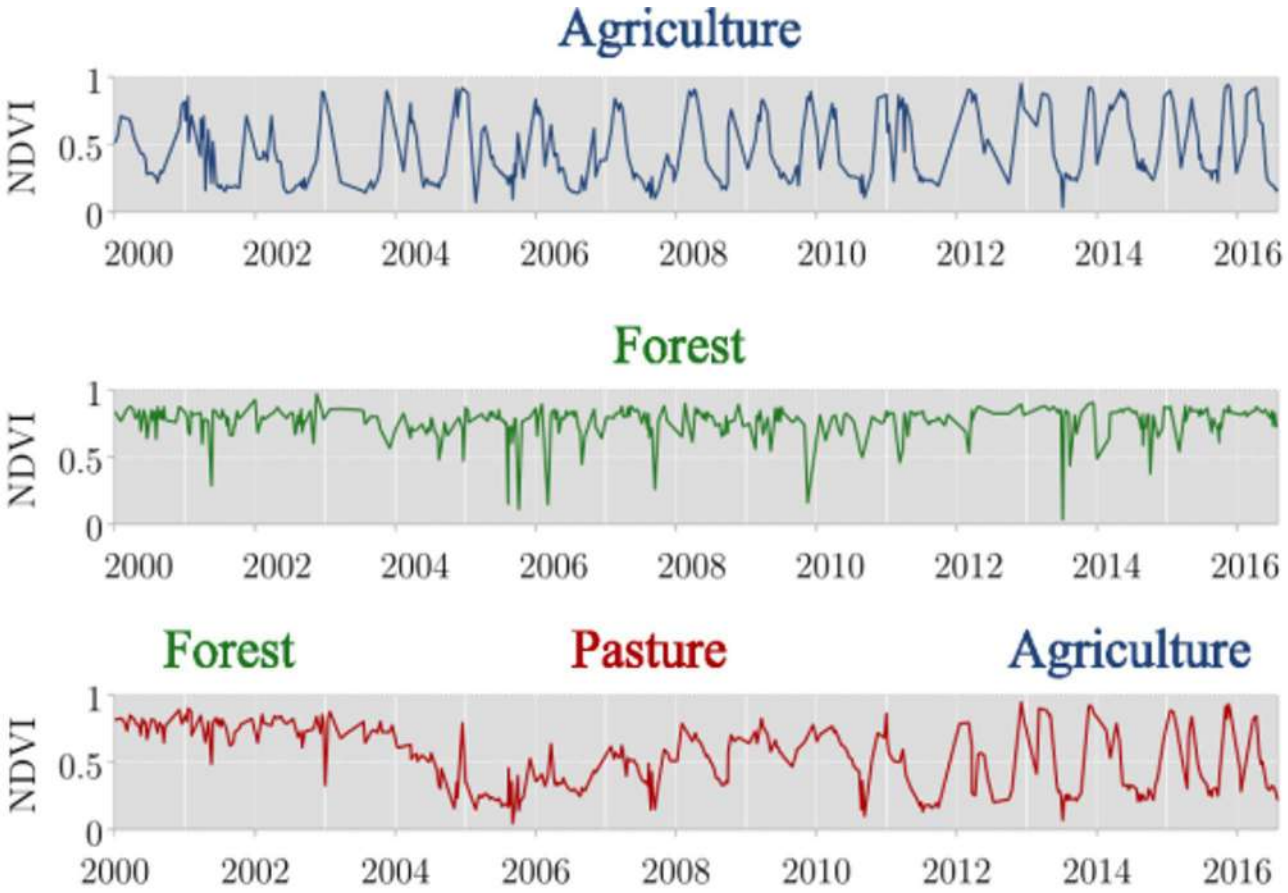


Image selection

Data cubes = regular partitions of space and time which may span multiple tiles

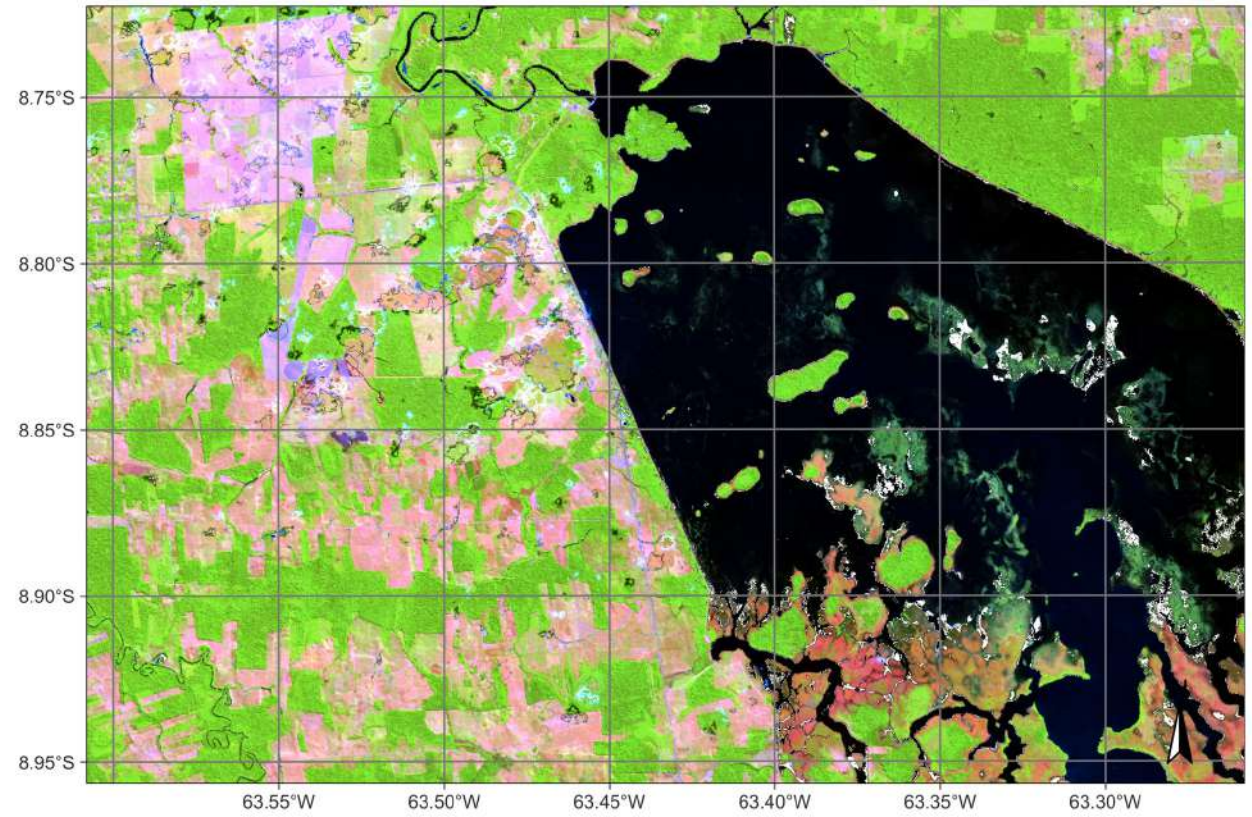
Data cubes: Access to image time series

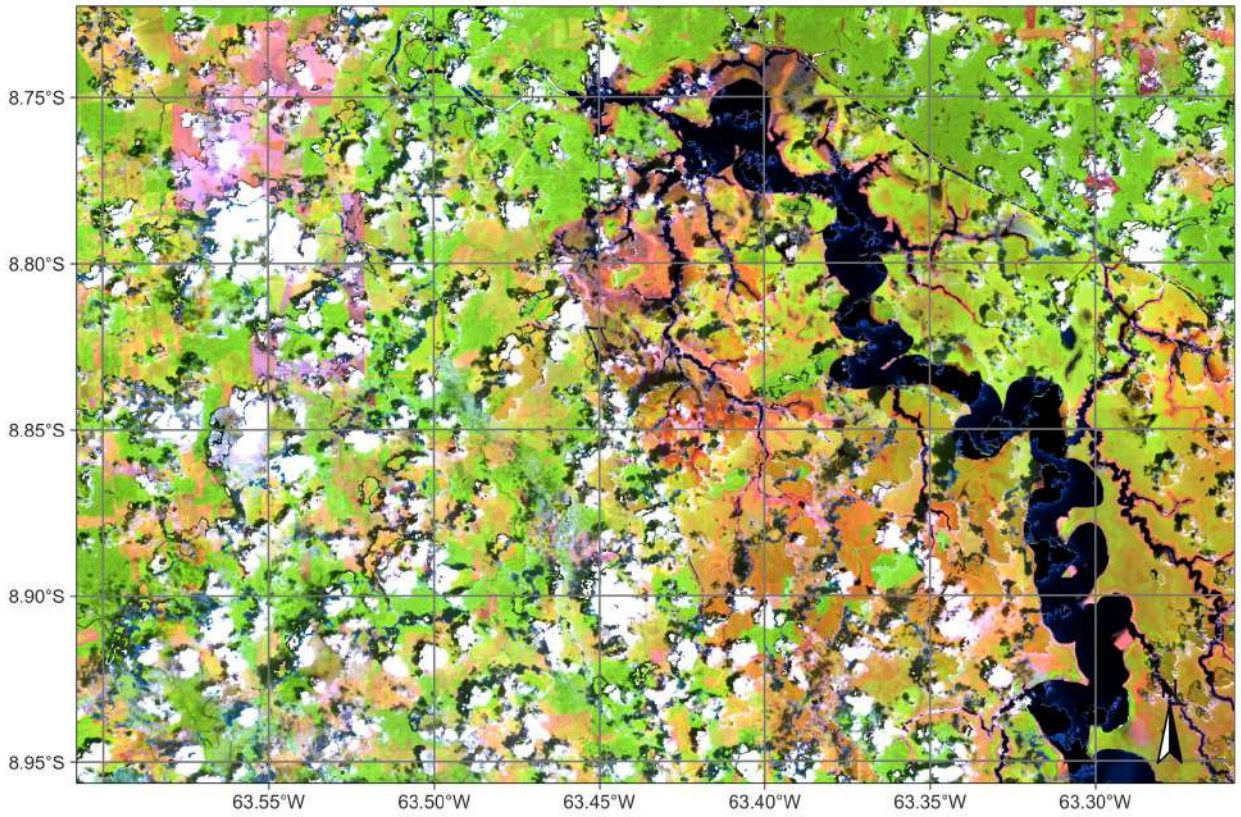




Graphics: Adaptation of material of Victor Maus

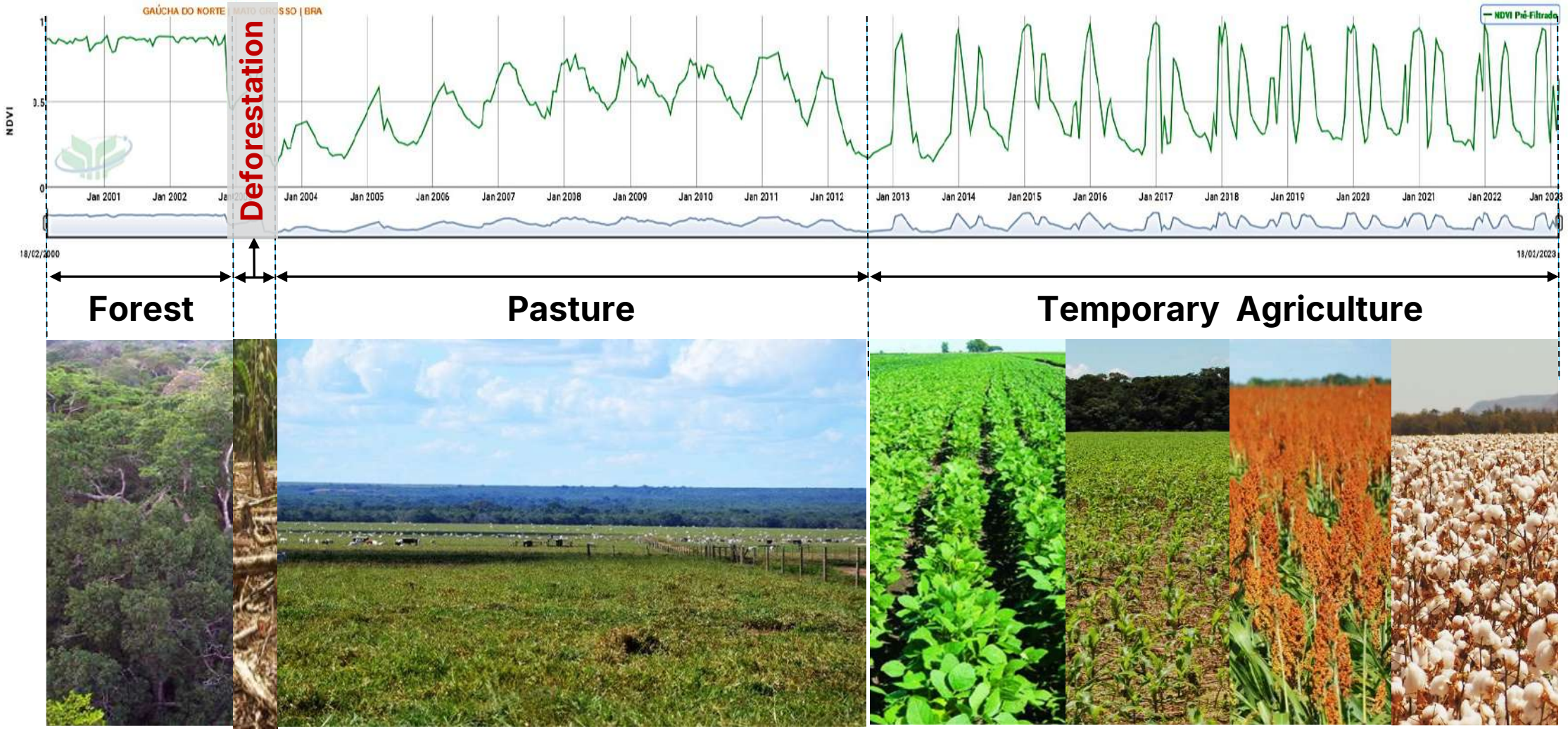
The need for image time series



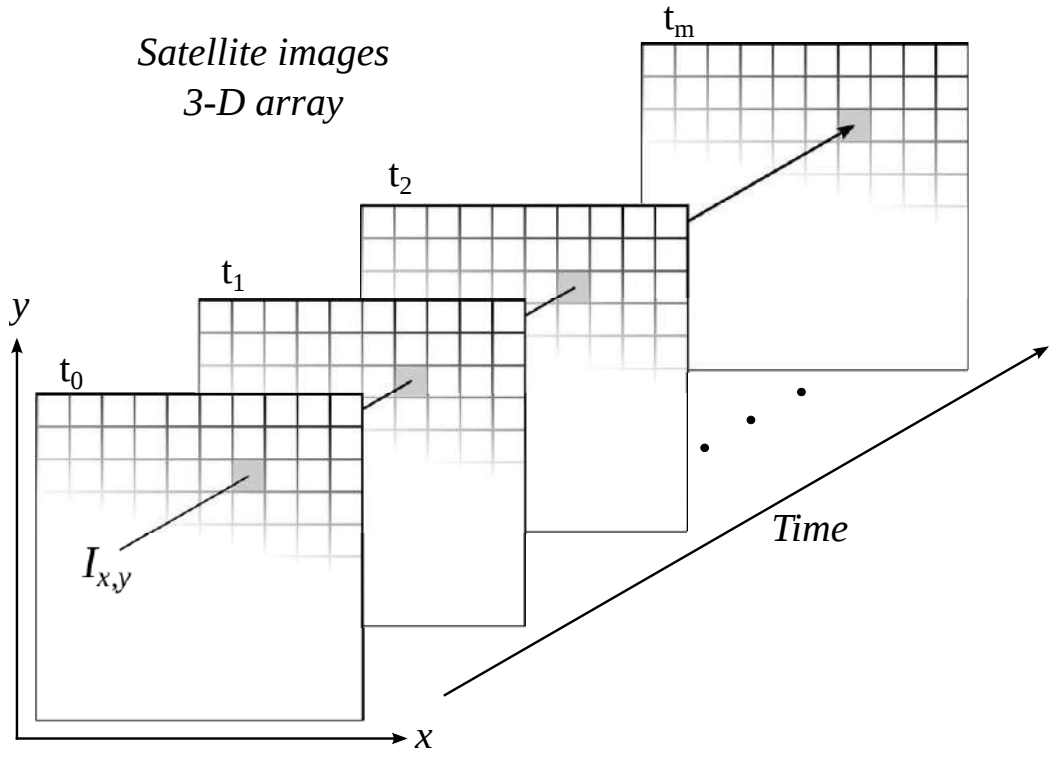


Single-date images cannot capture seasonal variations

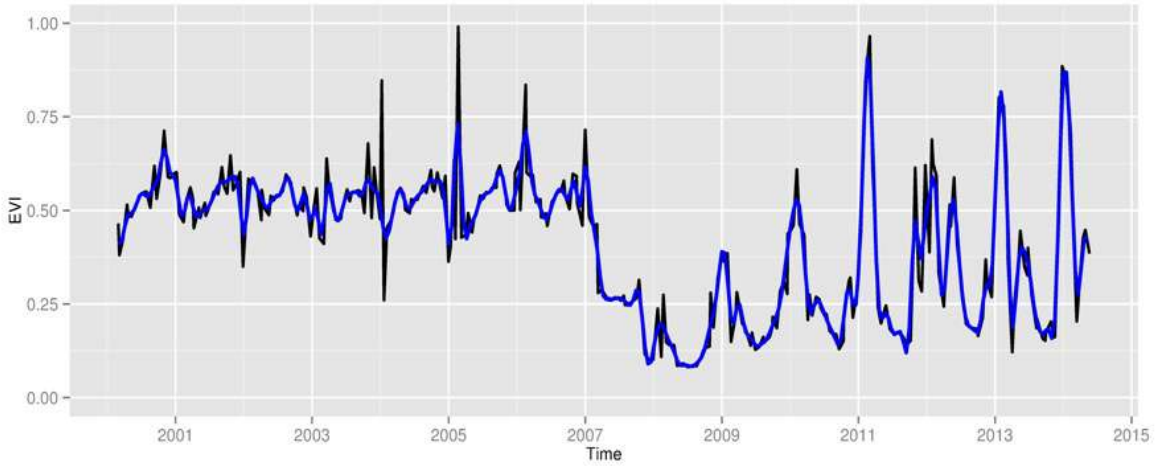
Time series capture change



Space first, time later or time first, space later?



Space first: classify images; compare results in time

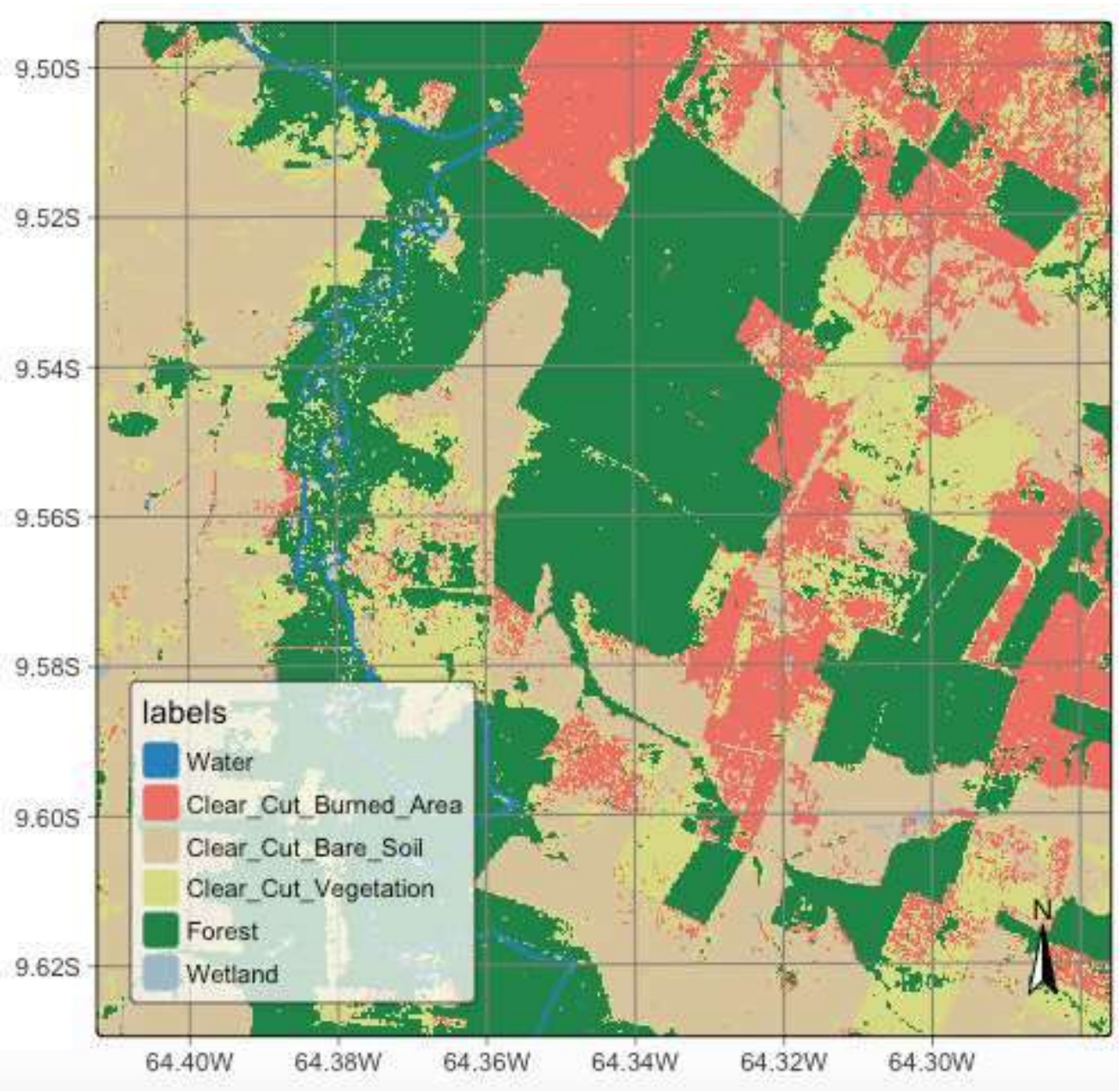


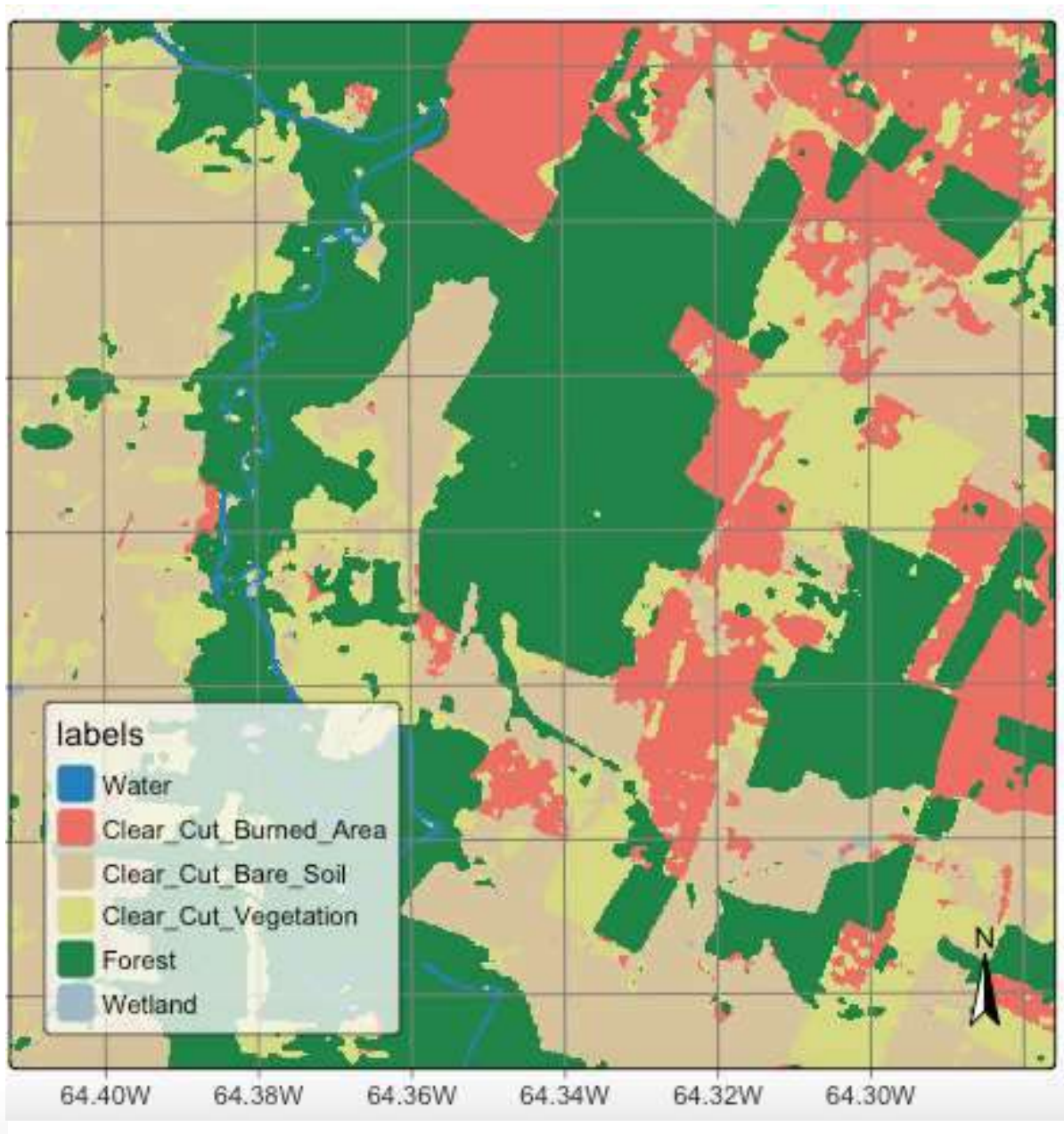
graphics: V Maus, author

Time first: classify time series; join results to get maps

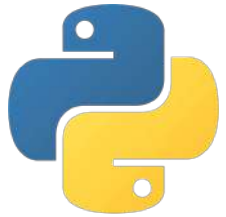
Unsmoothed classified map

Bayesian smoothing

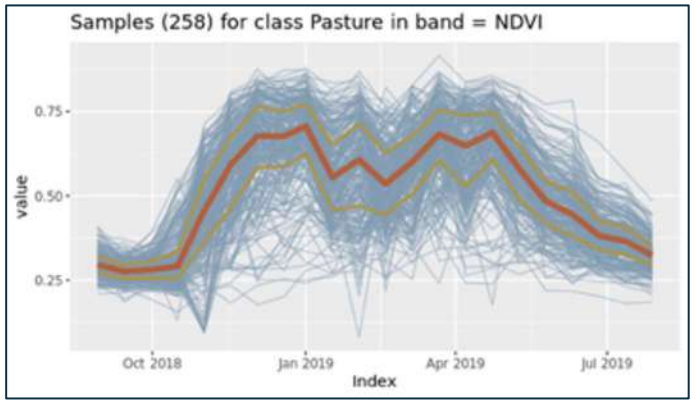


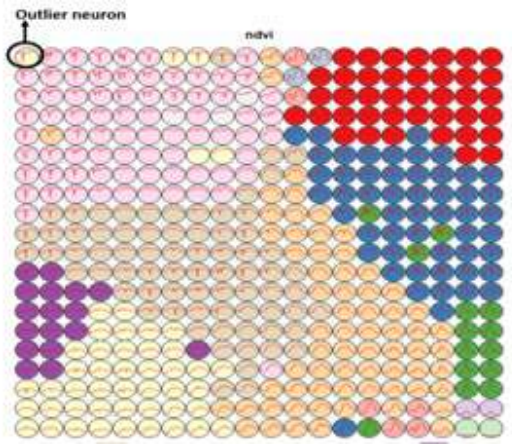


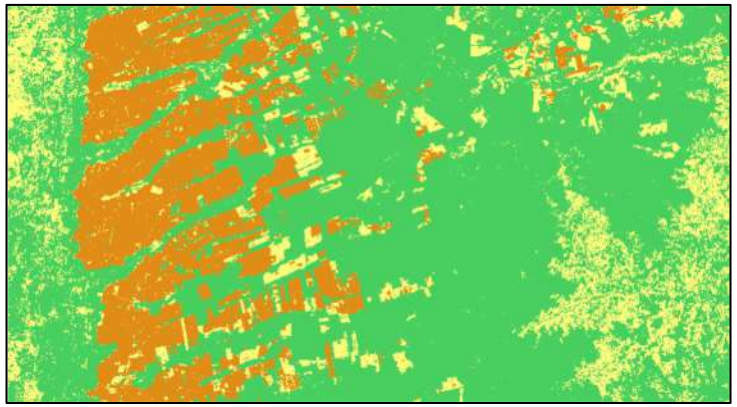
The SITS R Package



Satellite Image Time Series classification using SITS

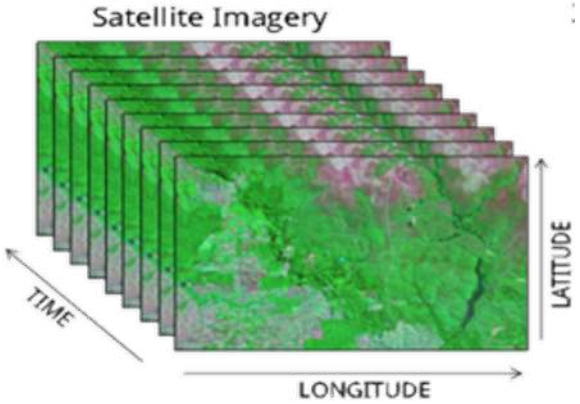


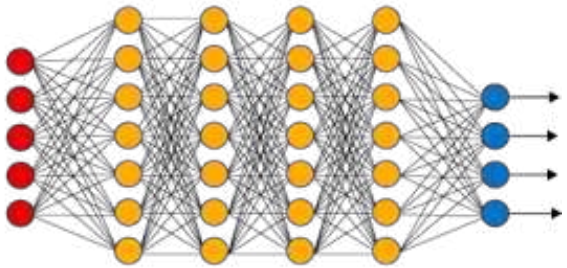


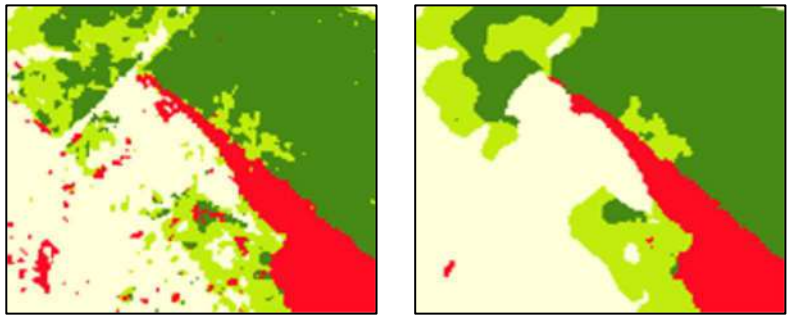


LULC samples ↔ Quality Analysis → LULC maps

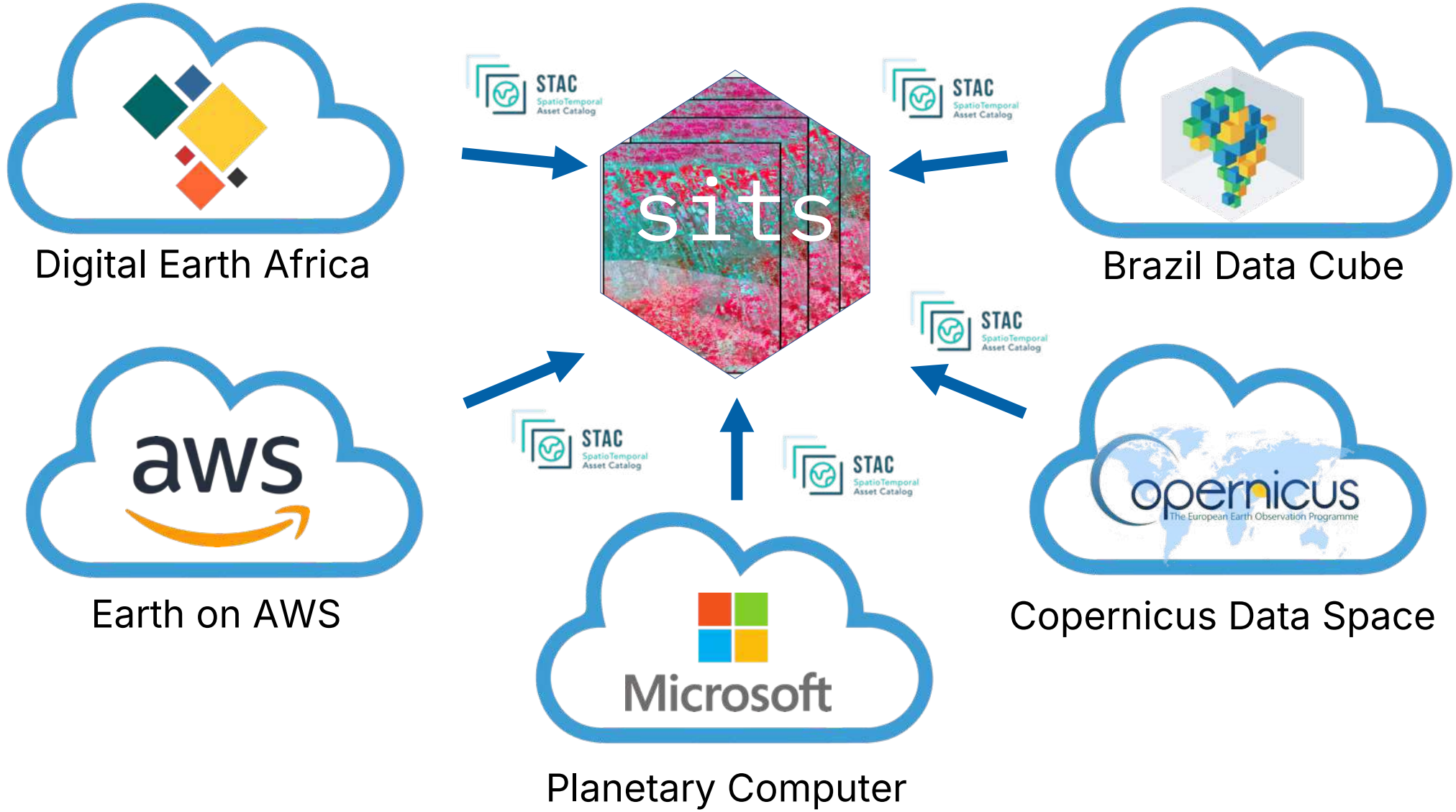
EO data cubes → ML models → Classification and smoothing







Acessing EO cloud services with STAC



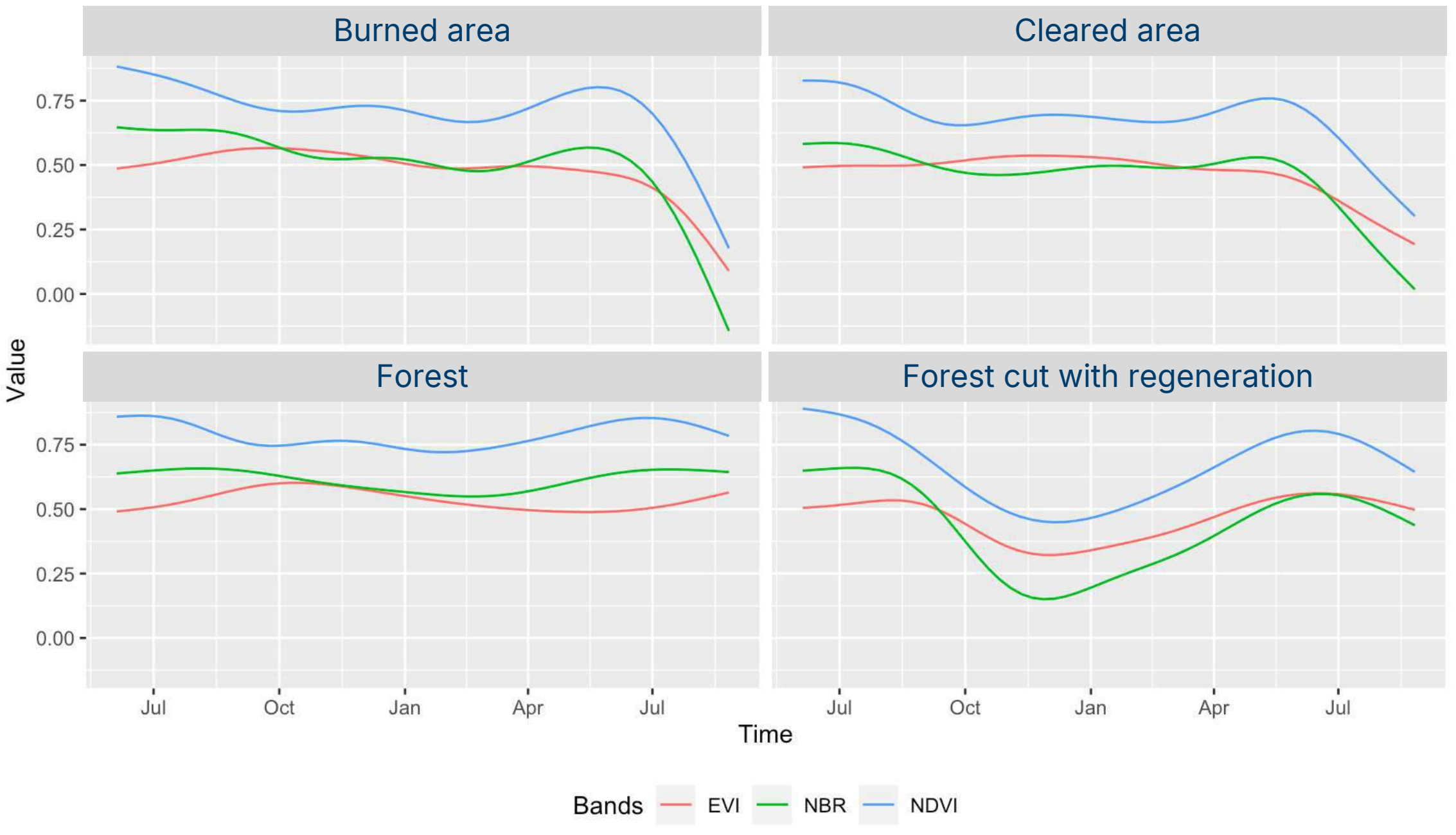
Objects exist, Events occur

Mount Etna is an object. Etna’s 2018 eruption was an event.

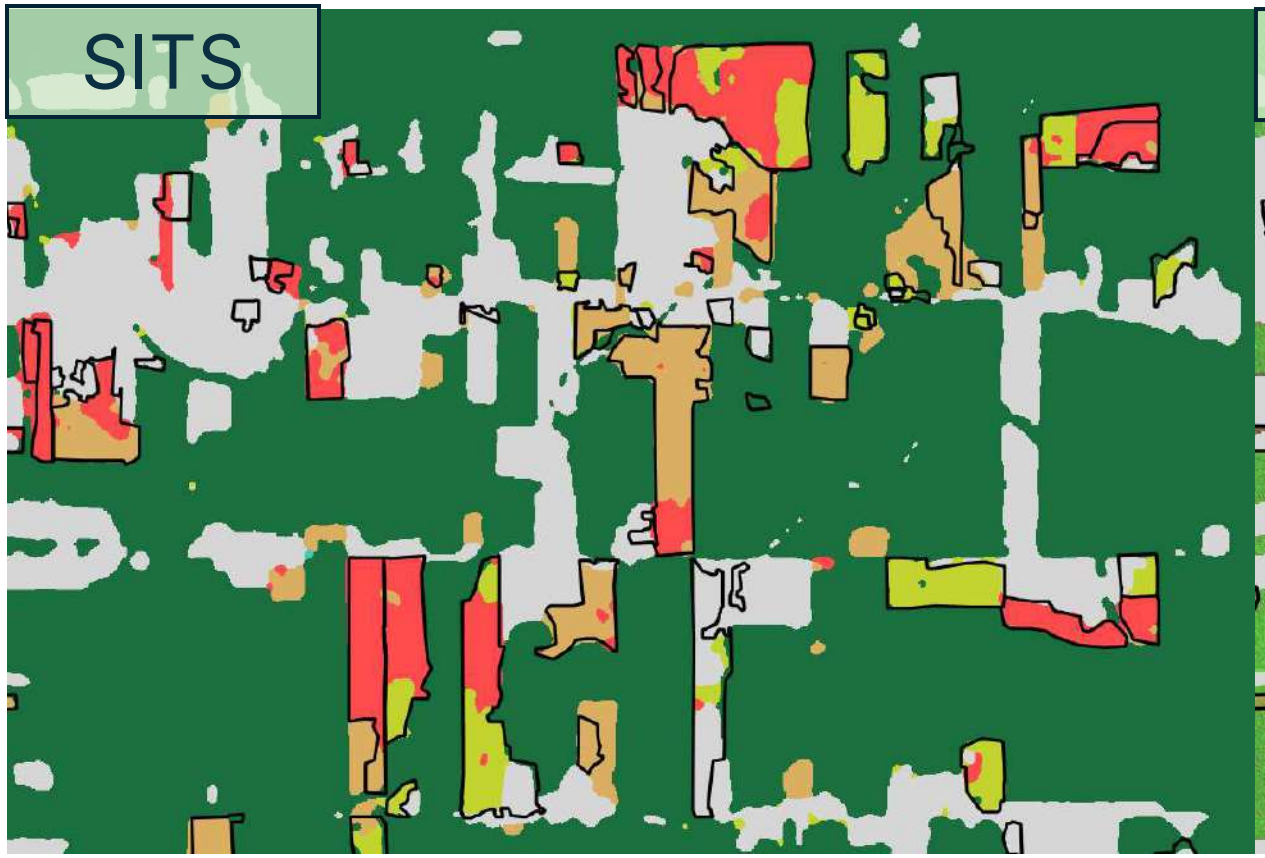
Deforestation = sequence of events

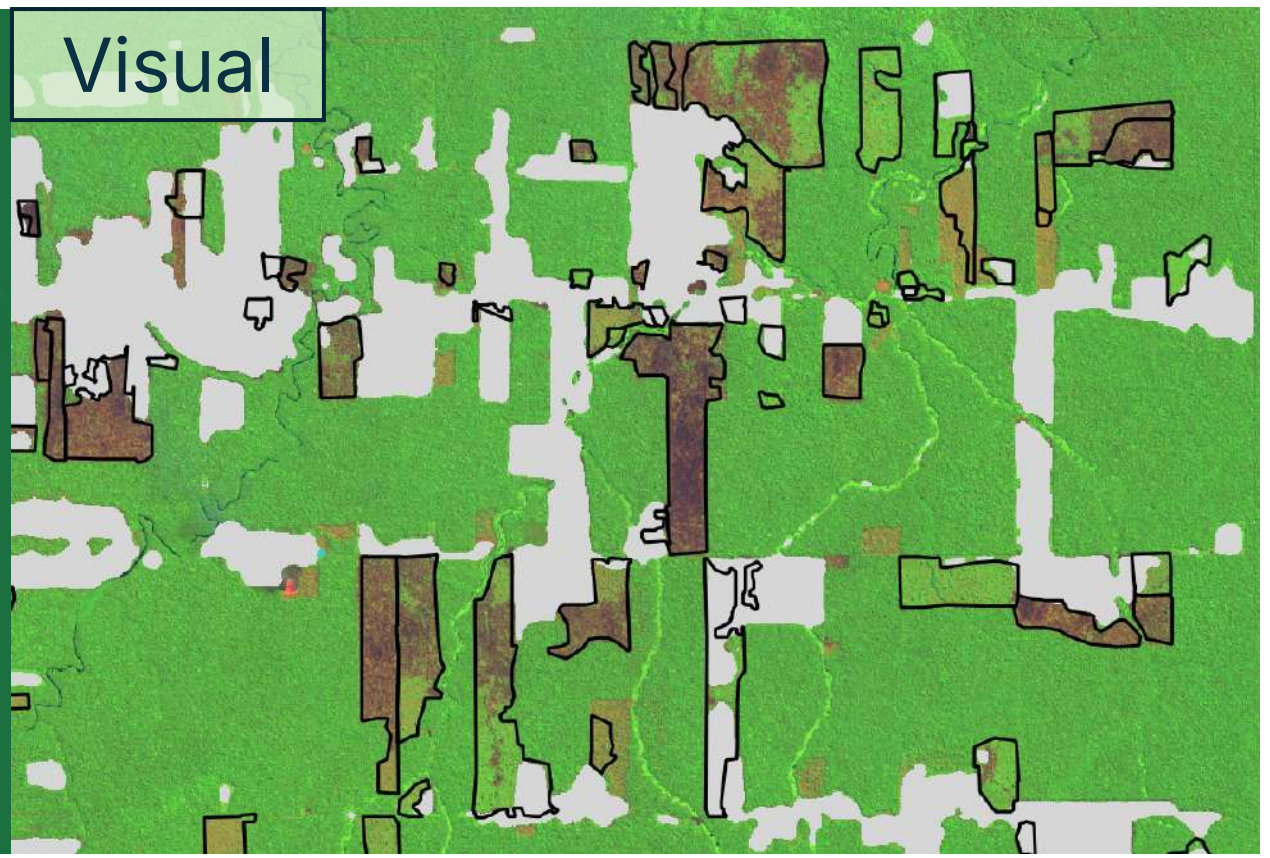
Images: Alamy, INPE

Event-based samples



Comparing SITS with visual interpretation

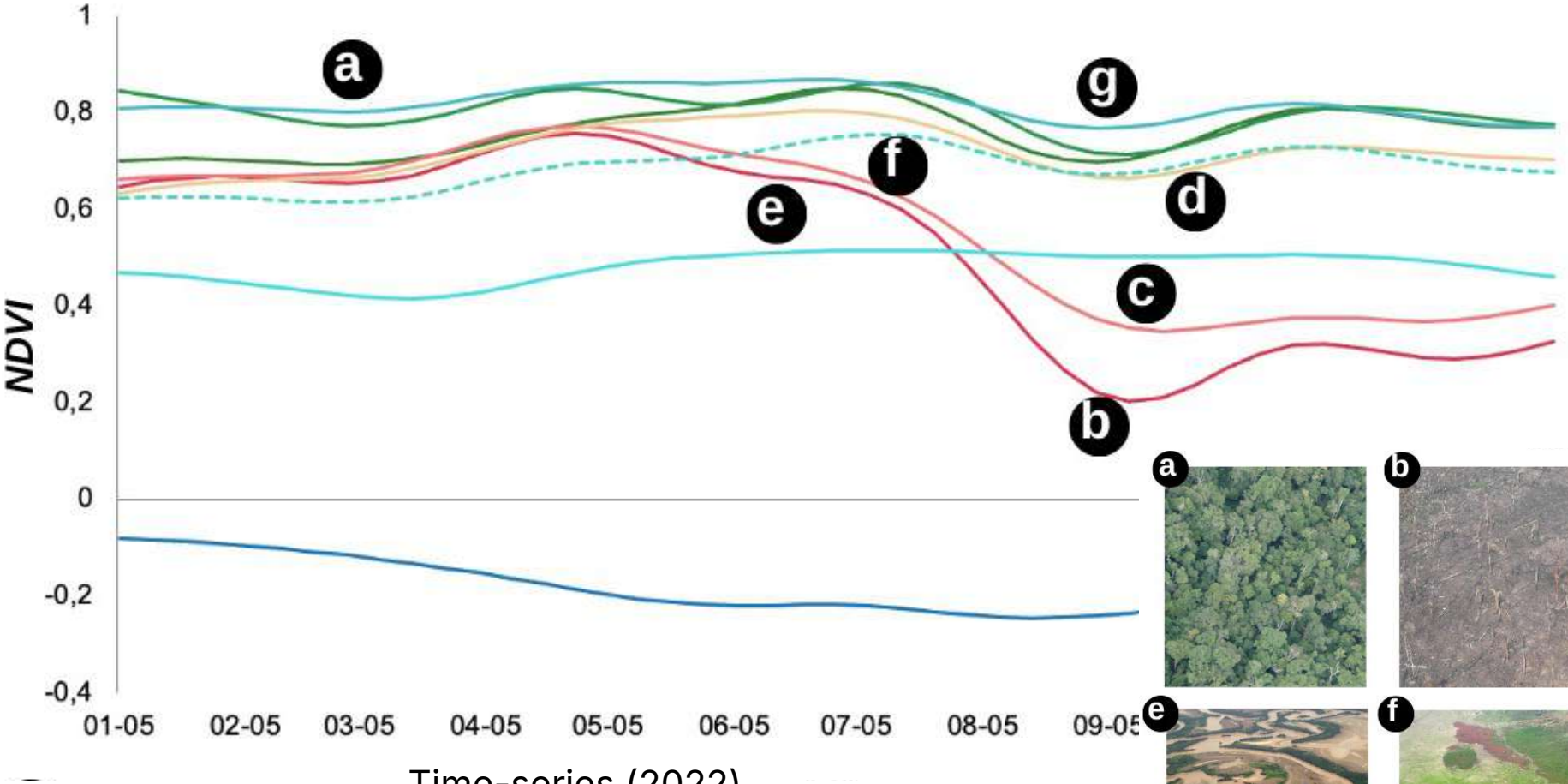




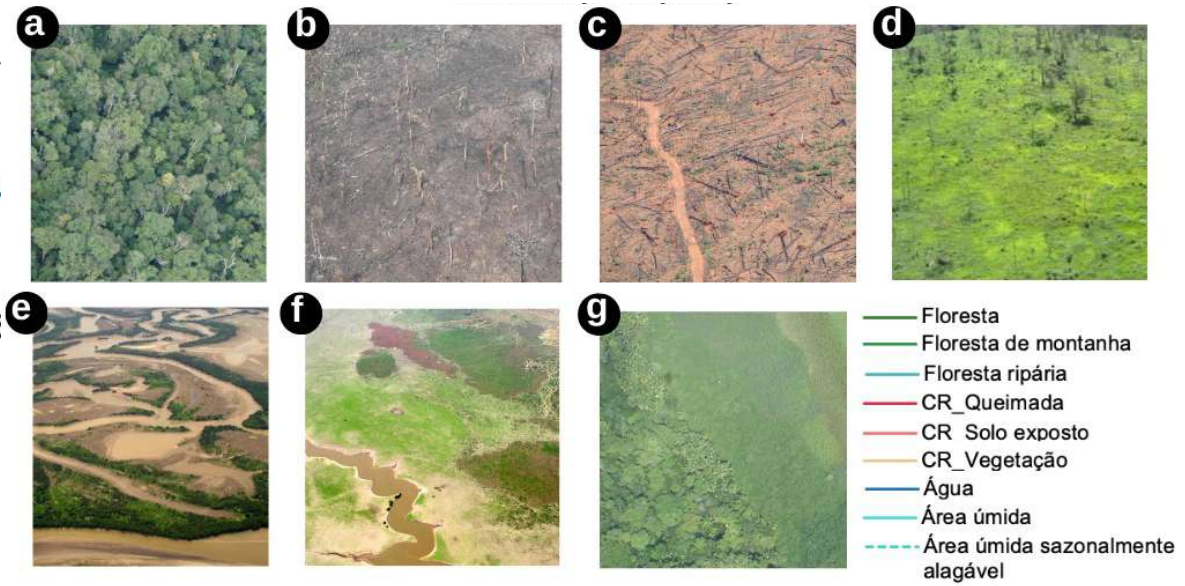
- CorteRaso_SoloExposto
- CorteRaso_Queimada
- Floresta
- CorteRaso_Vegetação
- Água
- Áreas úmidas
- Máscara de desmatamento
- Não Floresta

	PA	UA	F1 score
Clear Cut	0.94	0.97	0.95
Forest	0.98	0.91	0.94
Wetland	0.84	0.95	0.89
Water	0.96	0.95	0.95

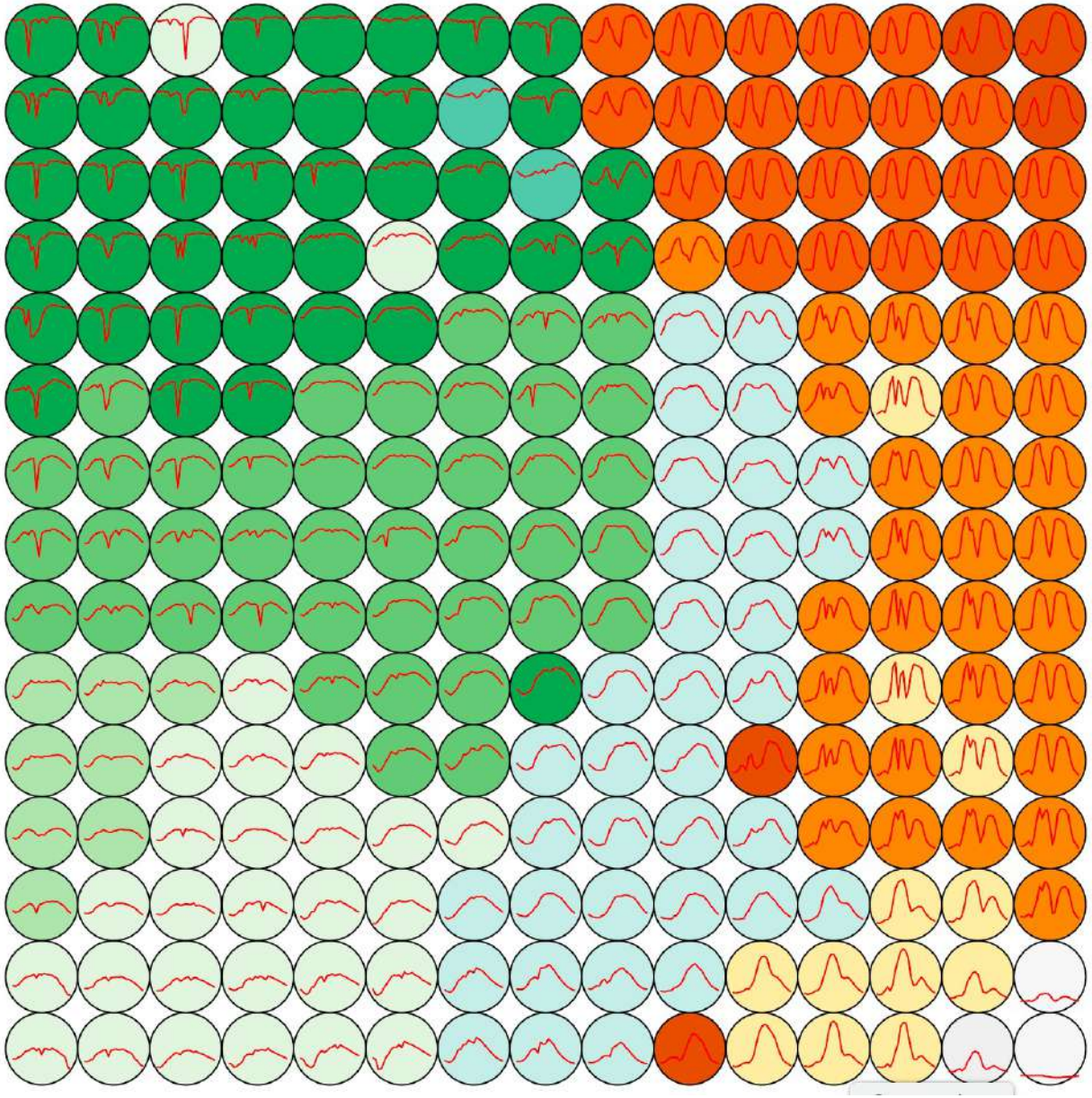
Good training data is key to success



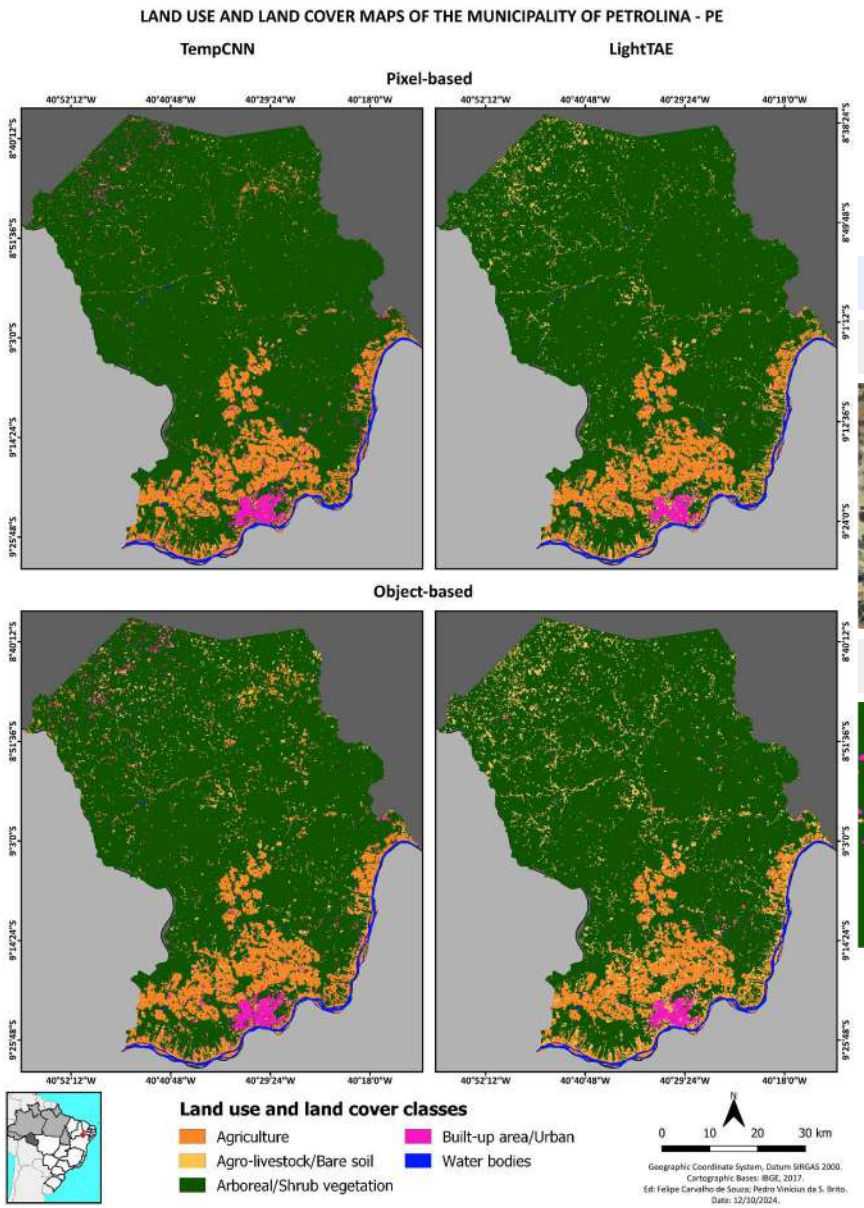
Time-series (2022)

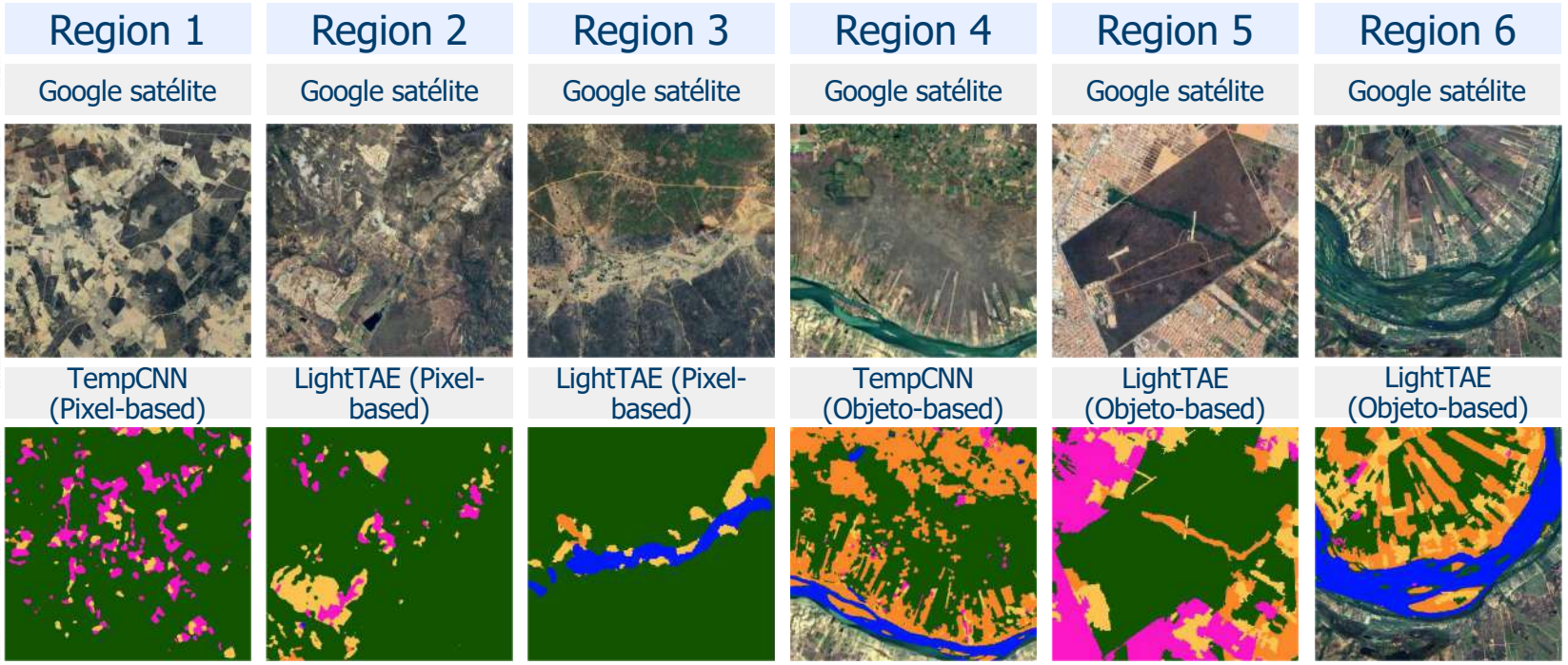


Good training data is key to success



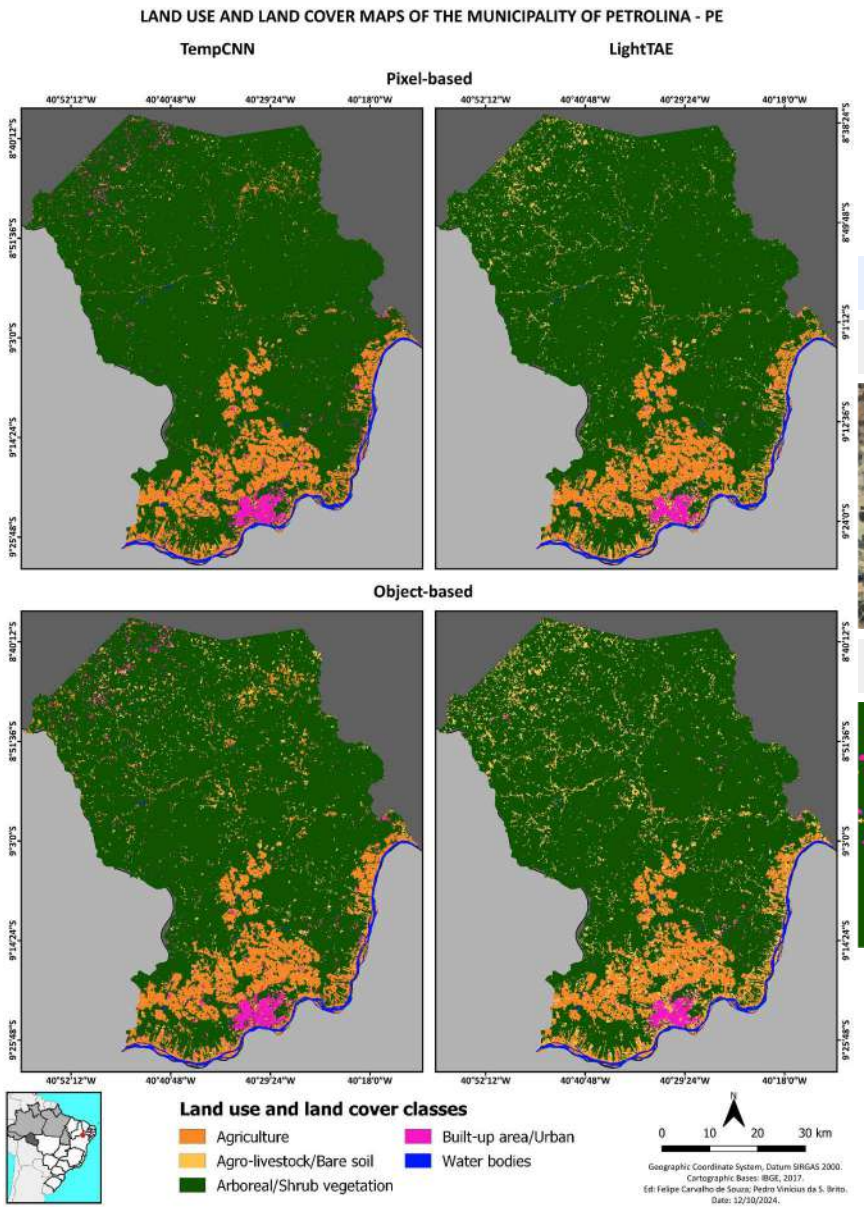
Model and map evaluation



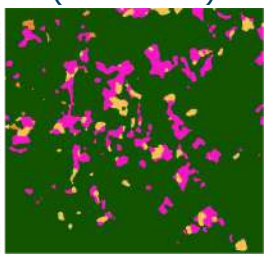
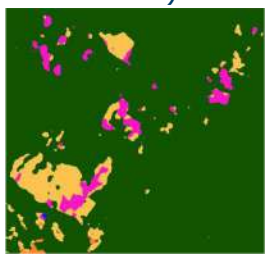
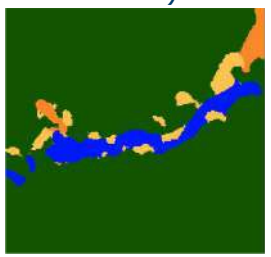
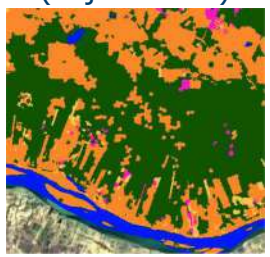


Source: Evaluating Convolution And Attention Time Series Algorithms For Classification In Tropical Biomes, *Souza et al*, IGARSS 2025

Model and map evaluation



Kfold > 98% accuracy!!!

Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Google satélite	Google satélite	Google satélite	Google satélite	Google satélite	Google satélite
					
TempCNN (Pixel-based)	LightTAE (Pixel-based)	LightTAE (Pixel-based)	TempCNN (Objeto-based)	LightTAE (Objeto-based)	LightTAE (Objeto-based)
					

Source: Evaluating Convolution And Attention Time Series Algorithms For Classification In Tropical Biomes, *Souza et al*, IGARSS 2025

Model and map evaluation

Classes	Acc. Metric	Pixel TCNN	Pixel LTAE	Region TCNN	Region LTAE
Permanent	PA (%)	100	100	98.00	96.00
Crops	UA (%)	100	100	100	100
Urban	PA (%)	**98.00**	88.00	92.00	88.00
Area	UA (%)	**77.78**	95.65	83.64	95.65
Water	PA (%)	100	100	100	100
Bodies	UA (%)	100	100	100	100
Temporary	PA (%)	**26.00**	**76.00**	**46.00**	70.00
Crops	UA (%)	**92.86**	**86.36**	**88.46**	81.40
Natural	PA (%)	**100**	100	**100**	100
Vegetation	UA (%)	**68.49**	83.33	**71.43**	79.37
	OA (%)	84.80	92.80	87.20	90.80

Proper estimation accuracy methods for LULC Maps

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

Review

Good practices for estimating area and assessing accuracy of land change

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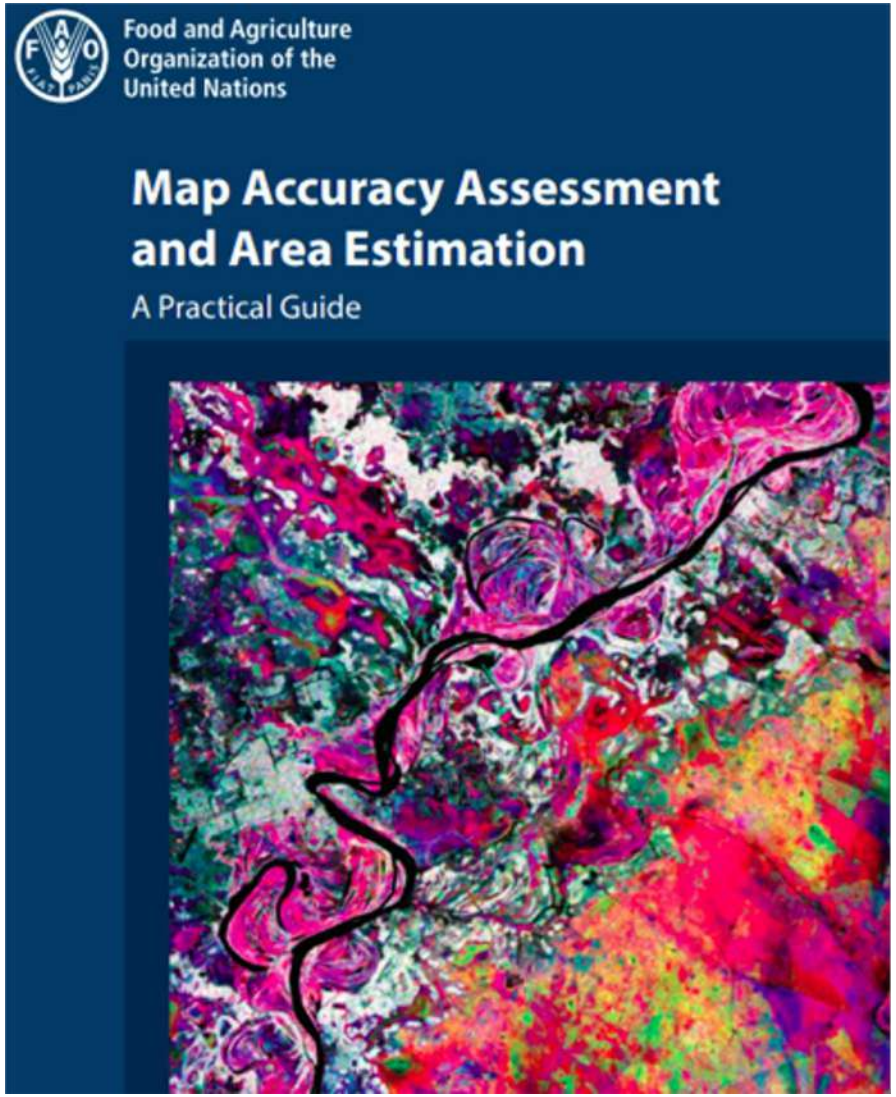
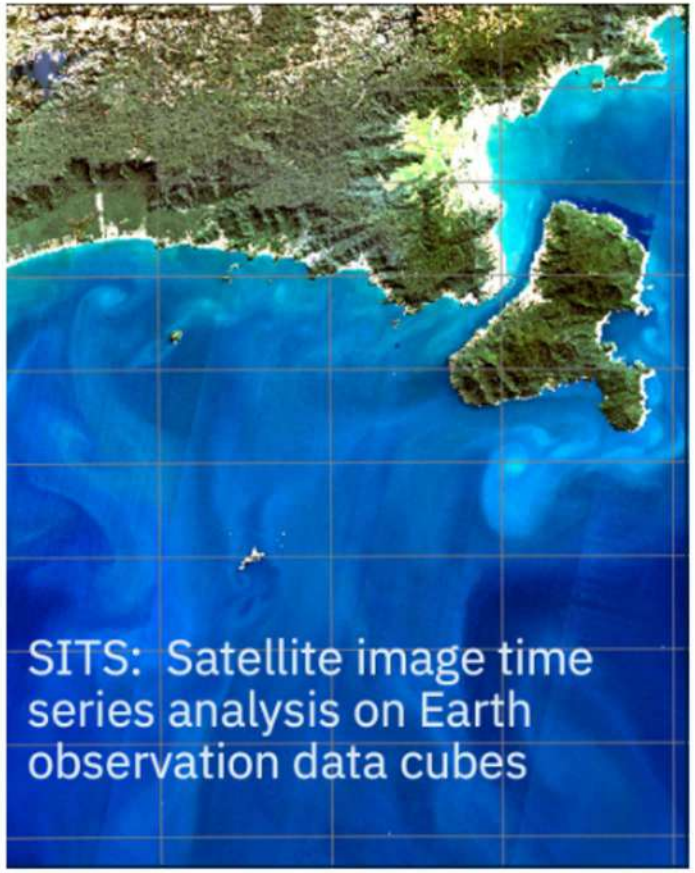
[b] School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK
[c] Laboratory of Geo-Information Science and Remote Sensing, Wageningen University, Droevendaalsesteeg 3, 6708 Wageningen, The Netherlands
[d] Department of Forest and Natural Resources Management, State University of New York, 1 Forestry Drive, Syracuse, NY 13210, USA
[e] Canadian Forest Service (Pacific Forestry Centre), Natural Resources Canada, Victoria, BC 12 V8Z 1M5, Canada



Satellite Image Time Series Analysis on Earth Observation Data Cubes

Greetings



Welcome to the age of big Earth observation data! With free access to massive data sets, we need new methods to measure change on our planet. This book will help you to use state-of-the-art tools to work with image time series. Time series are a powerful tool for monitoring change, providing insights and information that single snapshots cannot achieve. Combined with Earth observation data cube, time series analysis are a new and exciting paradigm. This book offers a comprehensive appraisal of this emerging discipline.

e-sensing.github.io/sitsbook