



BRAZIL DATA CUBE
brazildatacube.org

Big data, satellite image data cubes and time series analysis

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National Institute for Space Research (INPE)



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÕES





National Institute for Space Research (INPE), Brazil

Produce official information about deforestation, fire and land use / cover in Brazil.



National Institute for Space Research (INPE), Brazil

Identify what the deforested areas detected have become.



PRODES



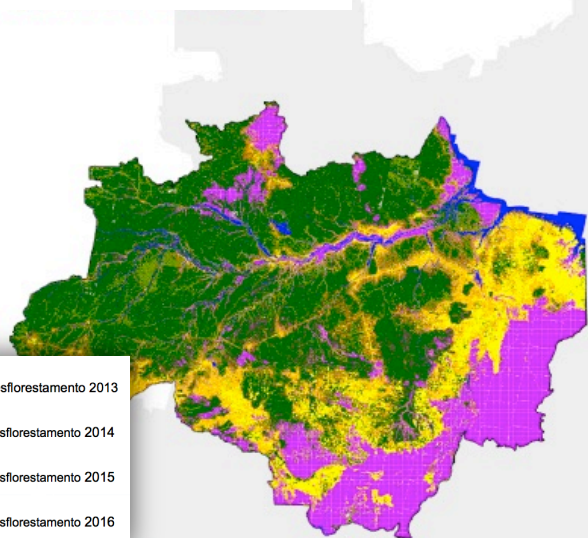
DETER



TERRACLASS

Deforestation monitoring

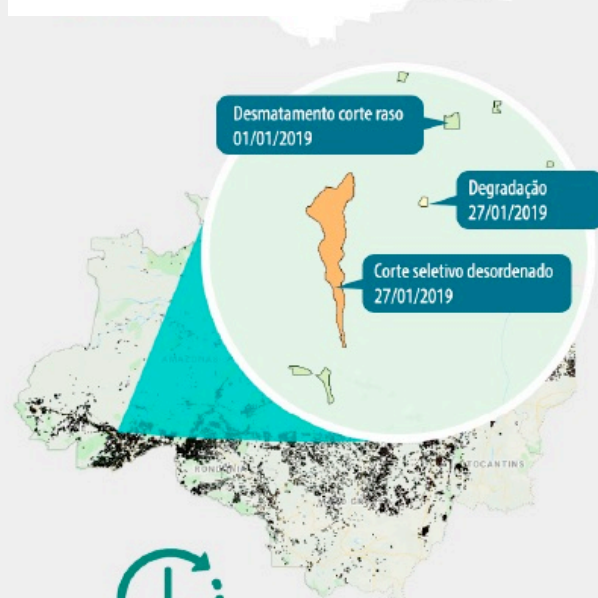
SINCE 1988



Annual maps

Near real time deforestation alerts

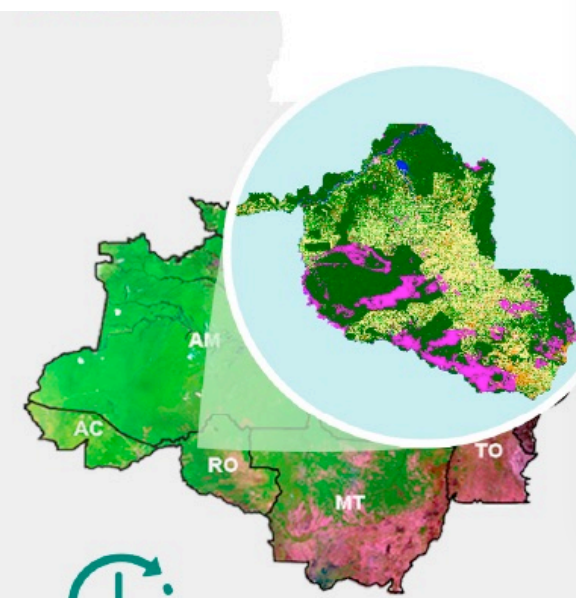
SINCE 2004



Daily alerts

Land use monitoring in deforested areas

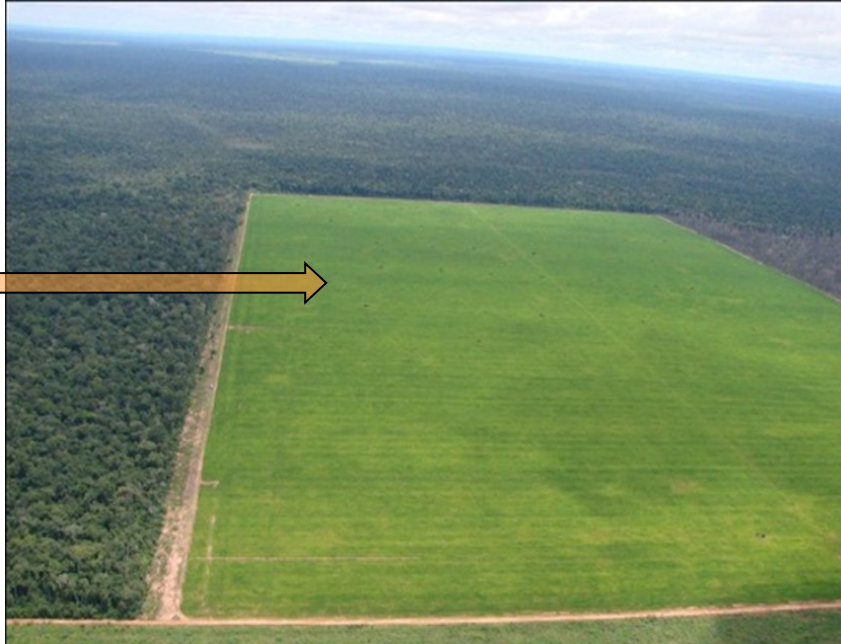
SINCE 2004



Biannual maps

Legenda

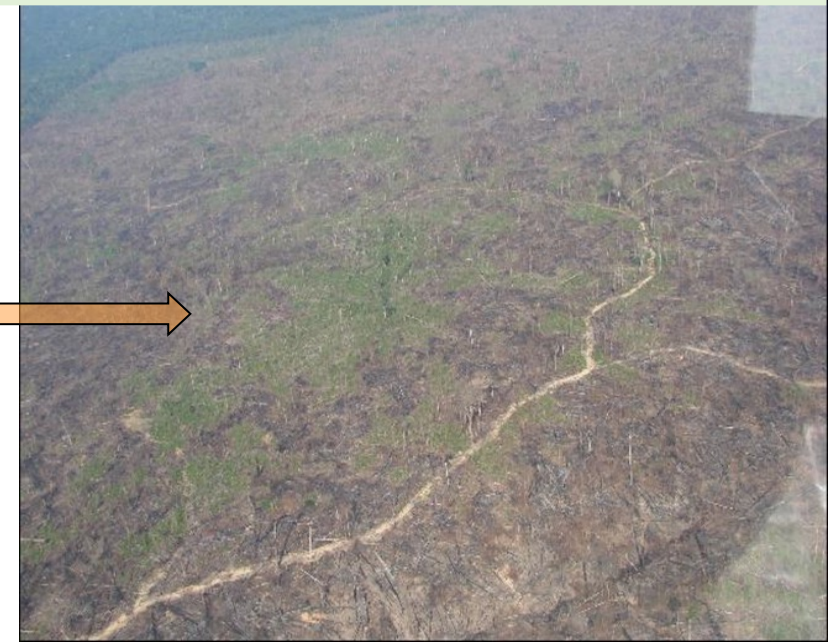
- Floresta
- Hidrografia
- Não floresta
- Desflorestamento 2008
- Agricultura anual
- Agropecuária
- Área urbana
- Mineração
- Outros
- Pasto com solo exposto
- Pasto limpo
- Pasto sujo
- Regeneração com pasto
- Vegetação secundária
- Área não observada



Landsat (30 meters)

Clear-cut deforestation by PRODES

Landsat (30
meters)





National Institute for Space Research (INPE), Brazil

Produce official information about deforestation, fire and land use / cover in Brazil.

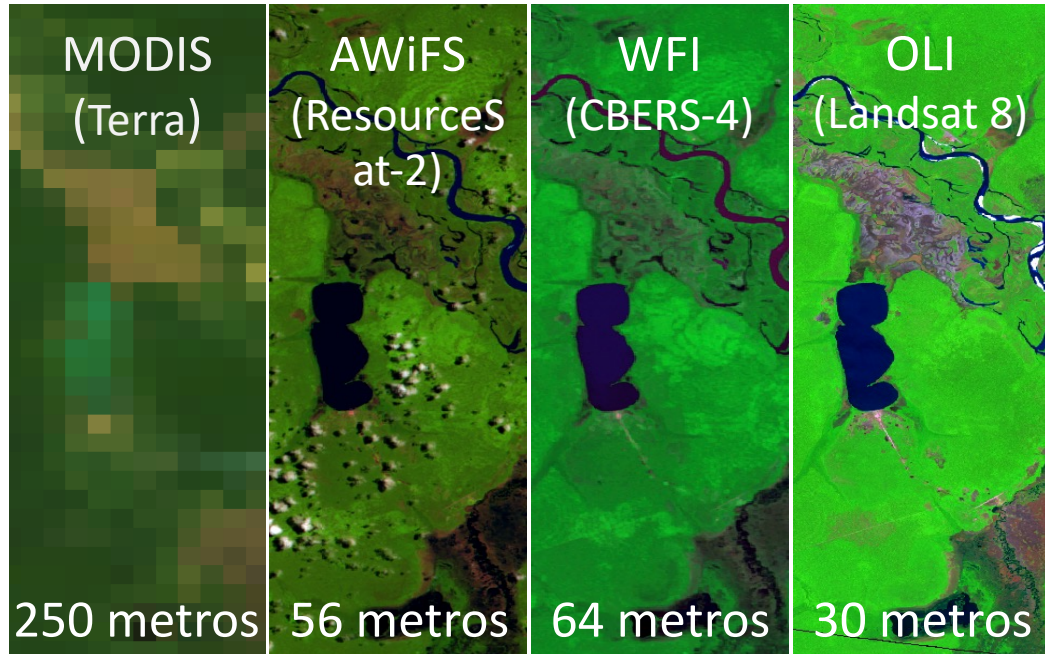
Develop innovative software systems for geospatial information management.

**Open
Data**



open source

Software developed by INPE to produce deforestation and land use/cover data from EO satellite images.



Visual interpretation of EO satellite images with distinct spatial and temporal resolutions.

Polygons of deforested and degraded areas.

Landsat (30 meters)





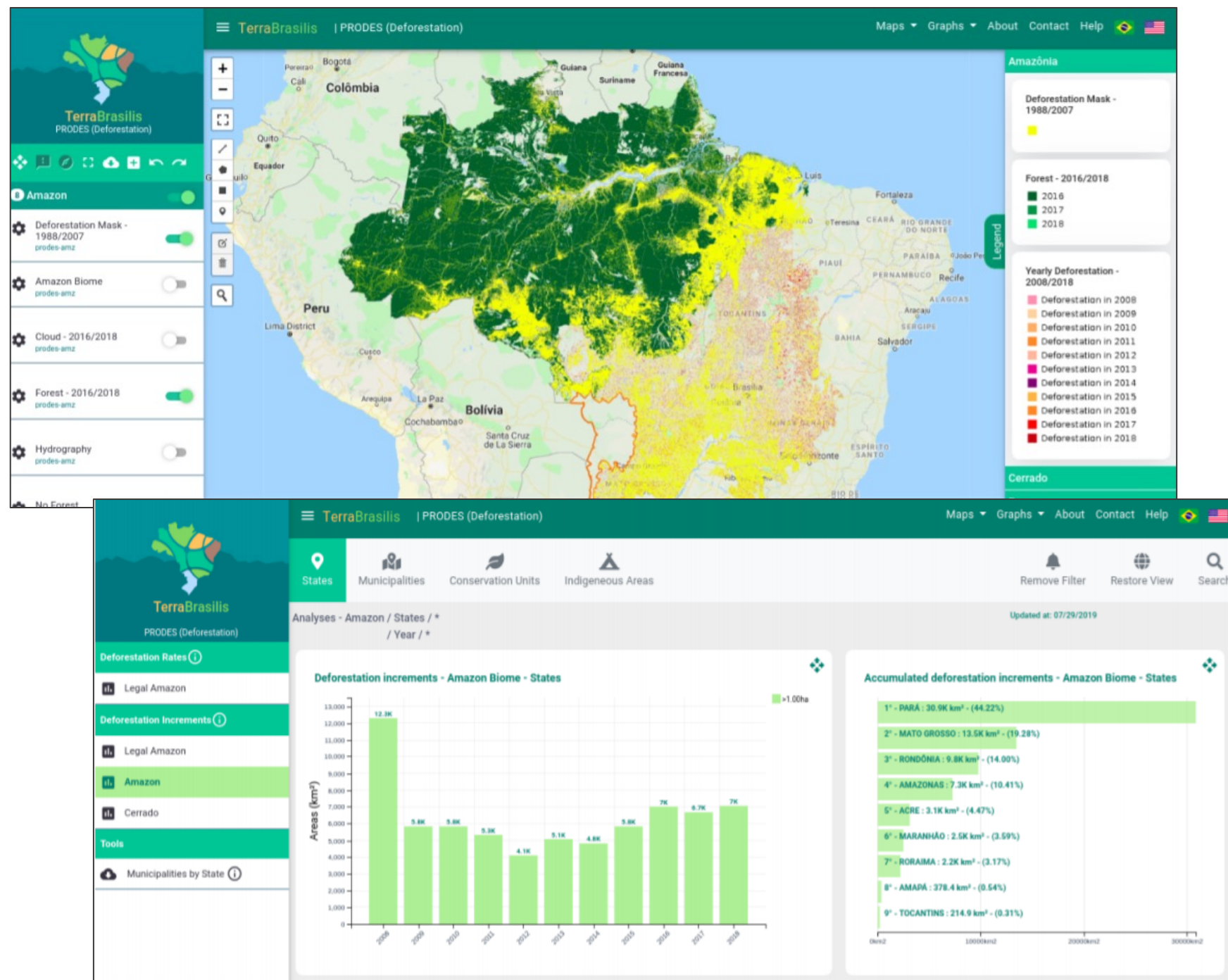
TerraBrasilis

Web portal to disseminate the deforestation data sets produced by PRODES and DETER.

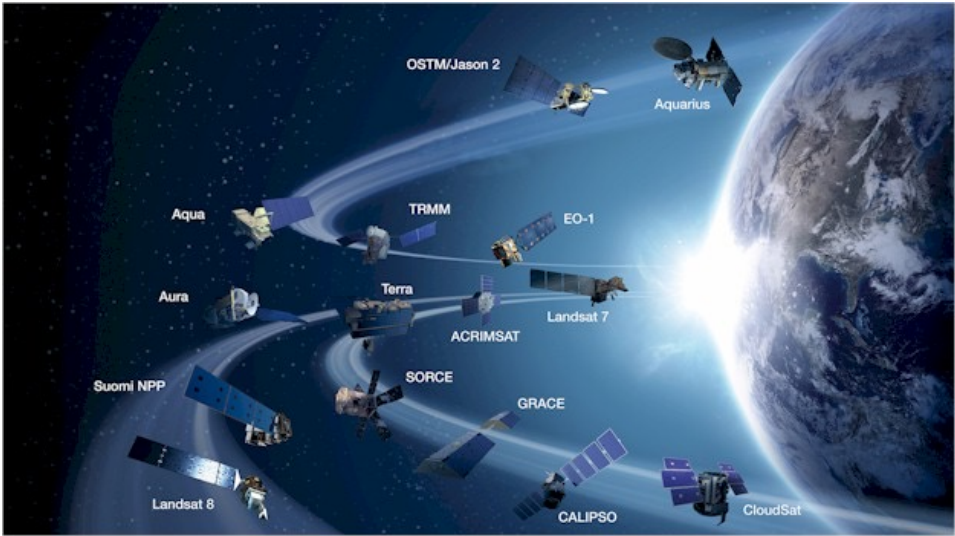
Open data.

Map visualization and dashboards.

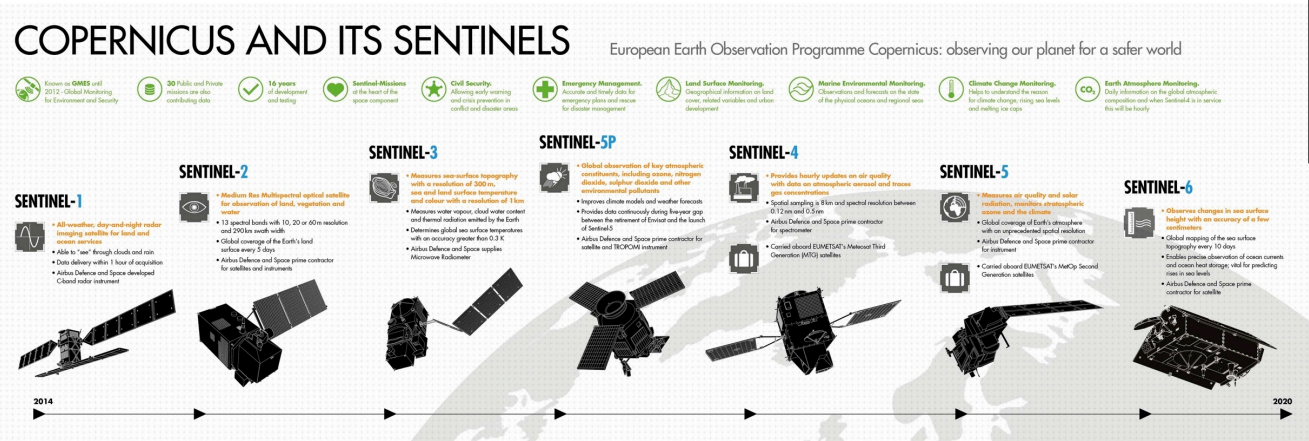
Spatial analysis tools.



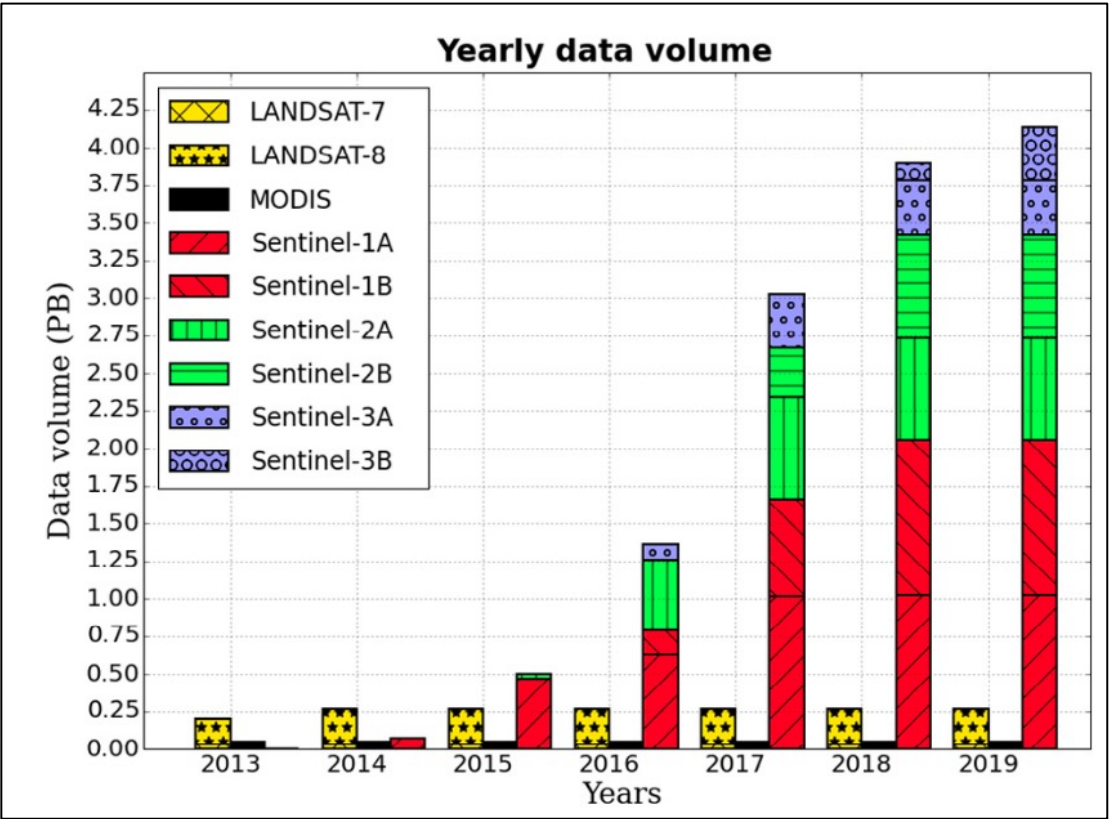
Challenge: Big data sets of EO satellite images



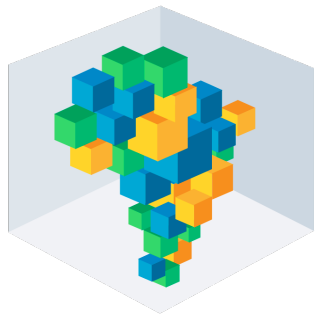
Source: eosps.nasa.gov



Source: www.copernicus.eu



Source: (Soille et al., 2018)



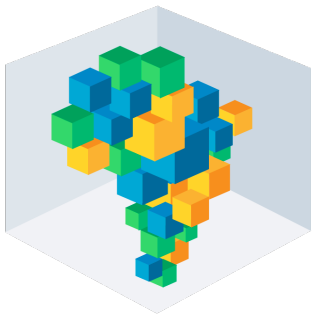
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2019

Produce **technological innovation** for the environmental monitoring projects of INPE.

Potential of **image time series analysis** and **machine learning** to produce land use and cover information from **big EO data**.



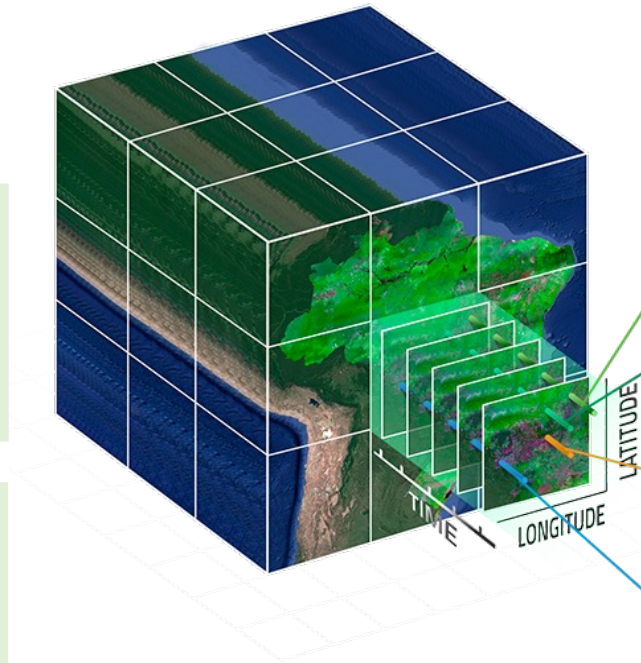
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Big data of remote sensing
images modeled as
multidimensional data cubes

Big data technologies and
machine learning

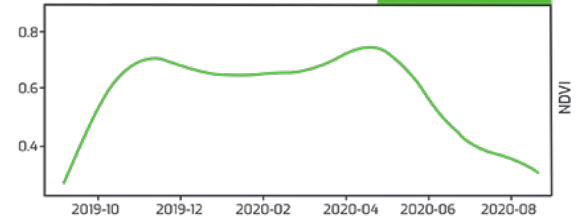
Image time series analysis

Land use and cover mapping

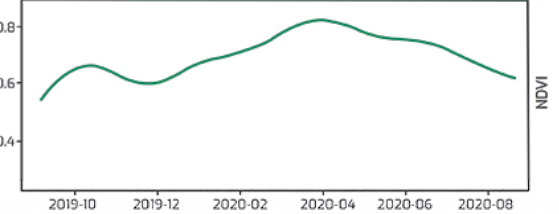


SÉRIES TEMPORAIS DE IMAGENS DE SATÉLITE

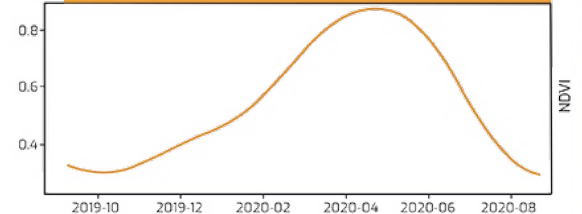
PASTAGEM



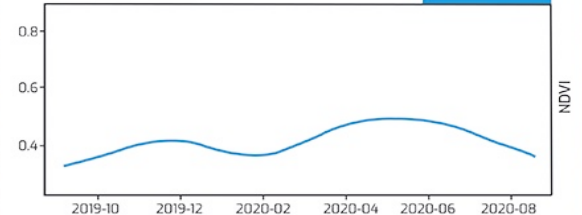
VEGETAÇÃO NATURAL PRIMÁRIA

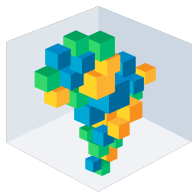


CULTURA AGRÍCOLA TEMPORÁRIA DE 1 CICLO



ÁGUA

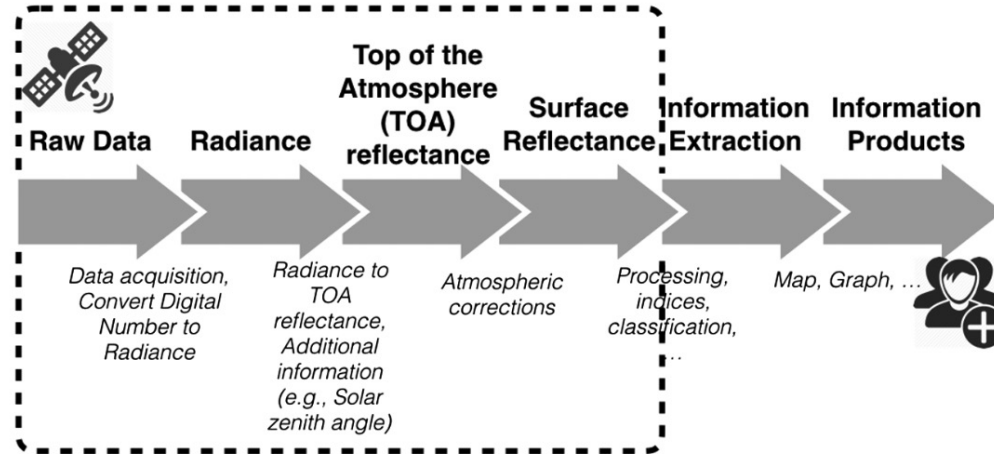




BRAZIL
DATA CUBE

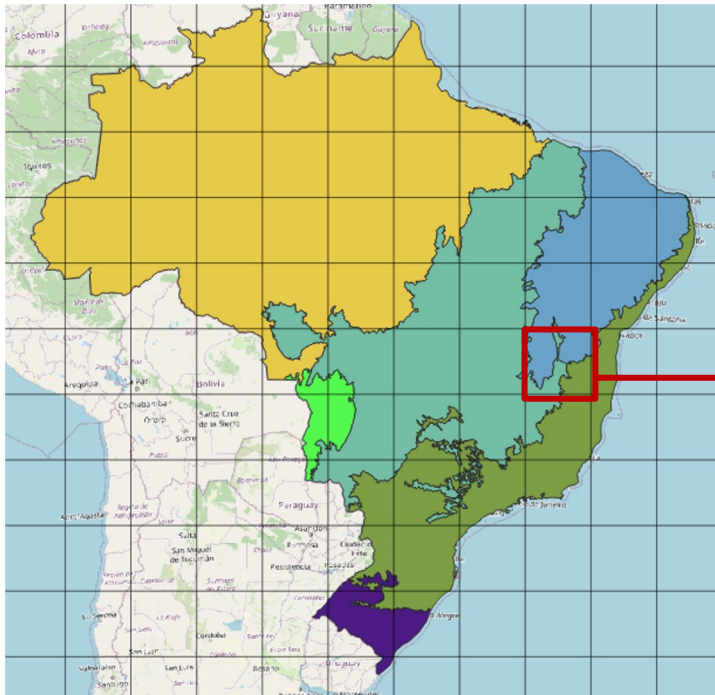
ARD and EO Data Cubes for the entire Brazilian territory

2 Petabytes (PB)
remote sensing images

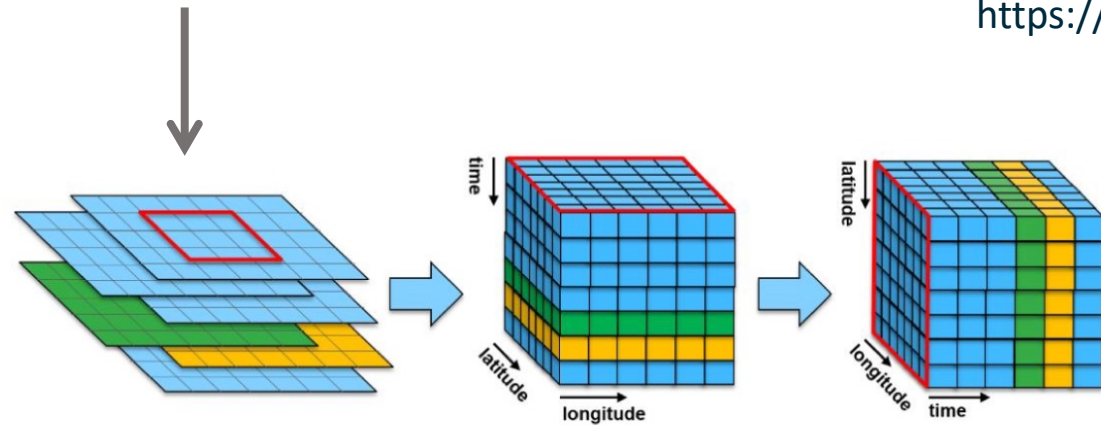


Analysis Ready Data production

Source: [Giuliani et al, 2017]



BDC Hierarchical Tiling System



**Collections of ARD
satellite imagens**

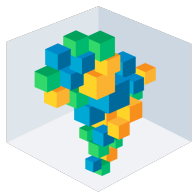
Multidimensional Data cubes

Source: [Kopp et al, 2019]

Sentinel-2
Landsat-8 / -9
CBERS-4 / 4A
(MUX / WFI)



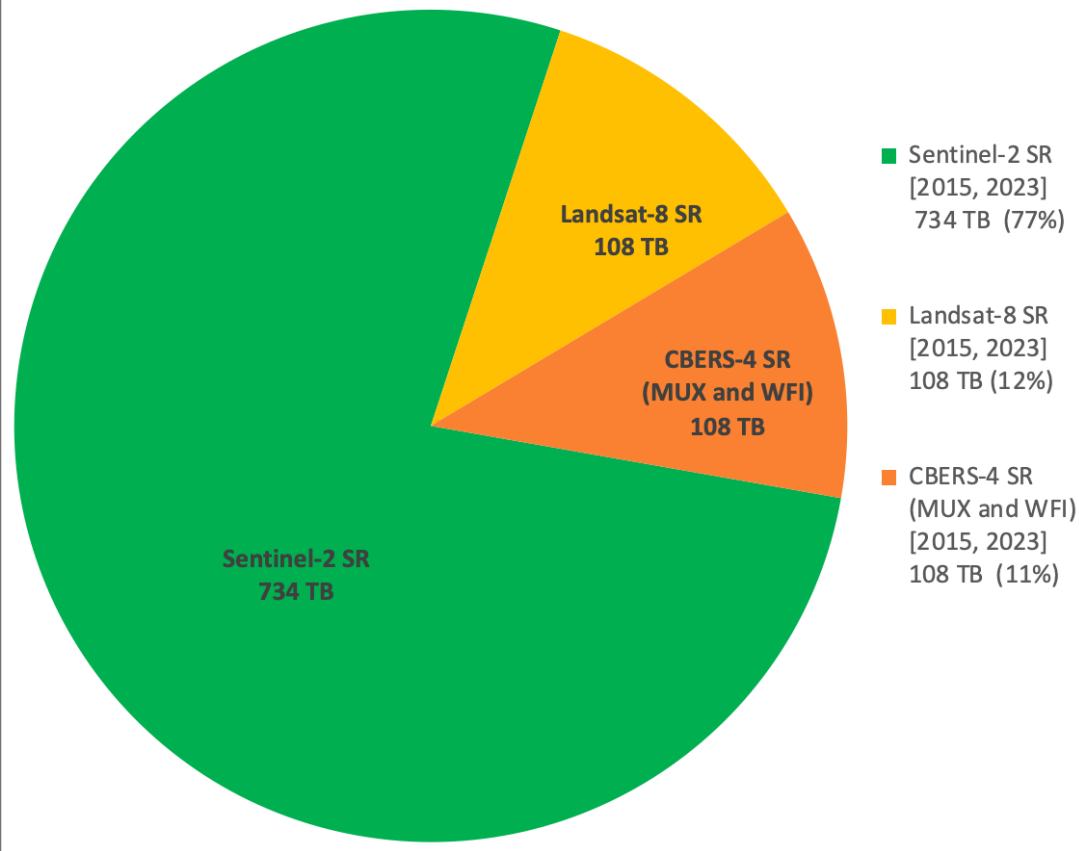
**CEOS Analysis Ready
Data (ARD) for Land:**
<https://ceos.org/ard/index.html>



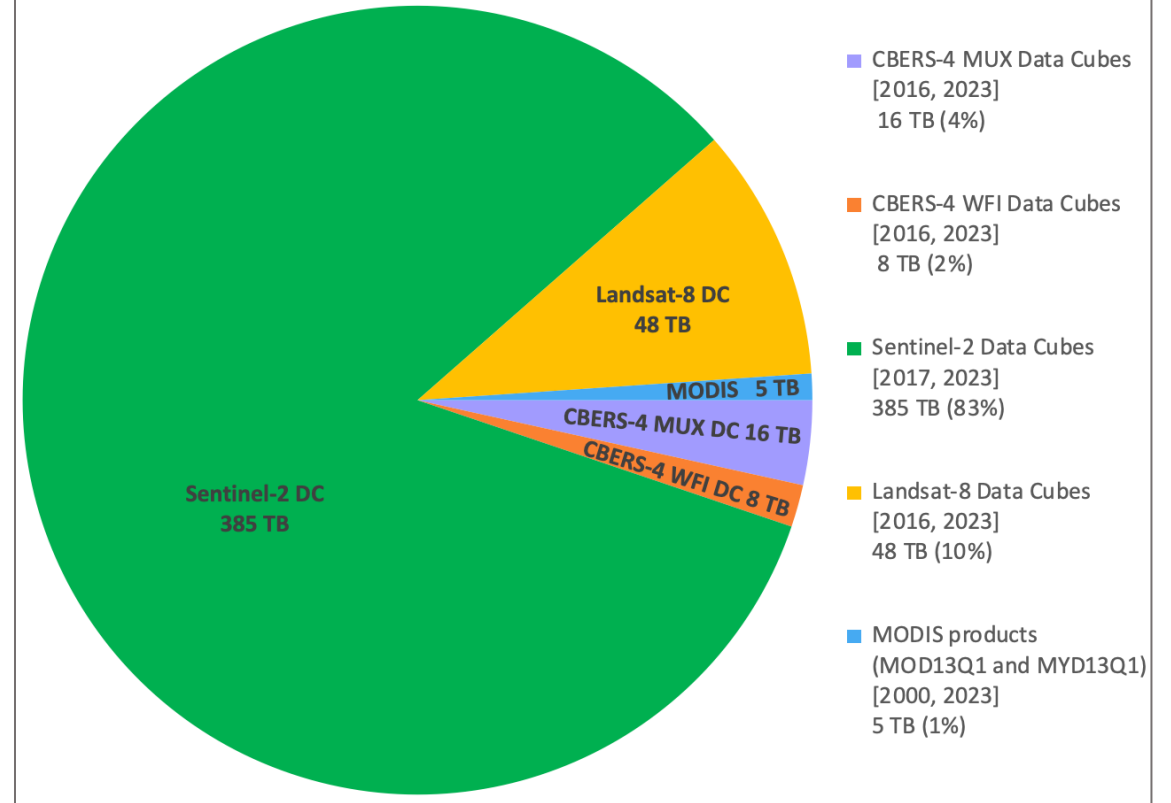
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Big data

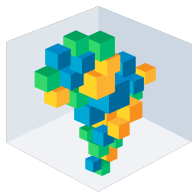
Data volume (TB) of surface reflectance (SR) images for Brazil



Data volume (TB) of Earth observation data cubes (DC) for Brazil

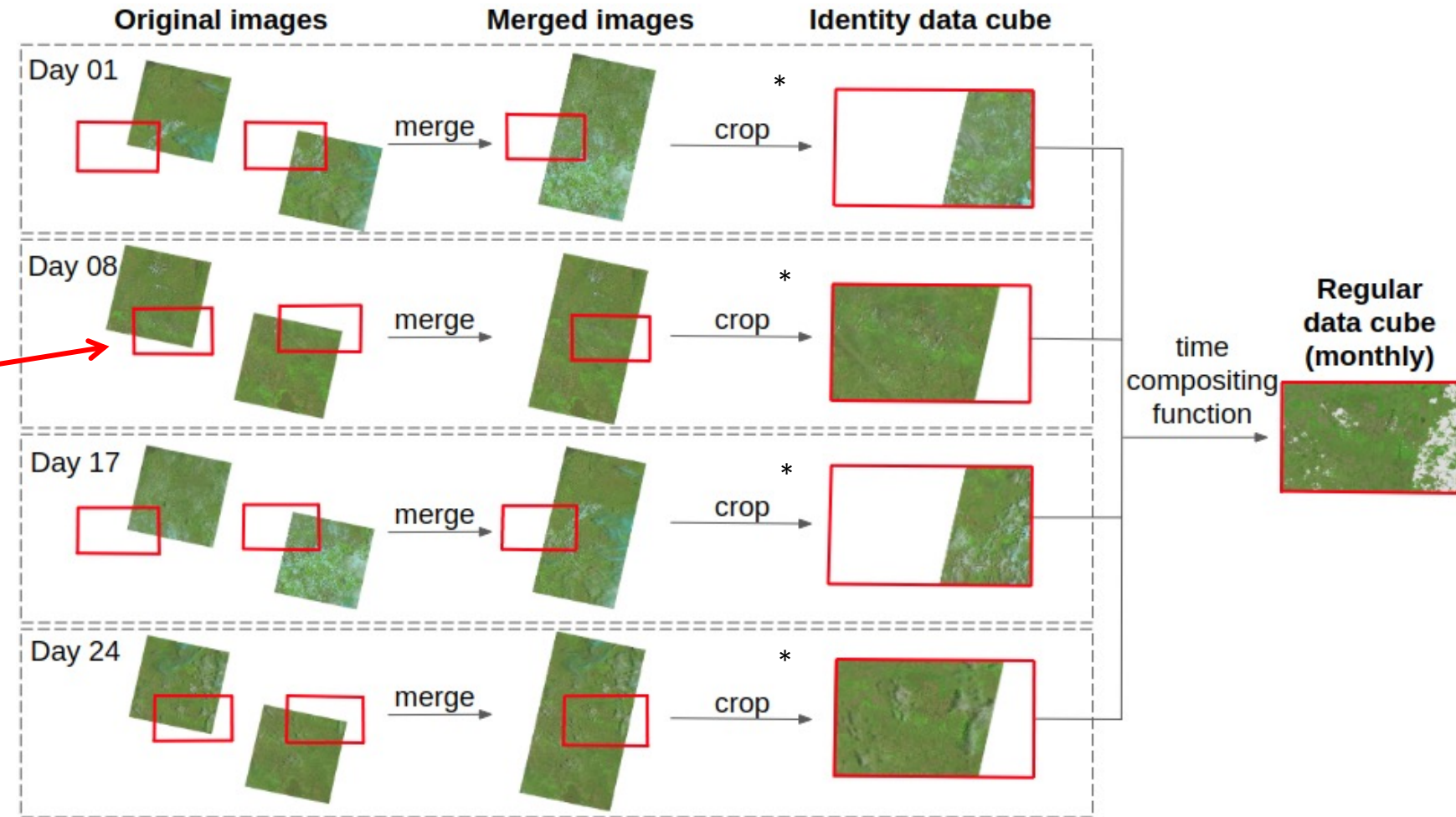
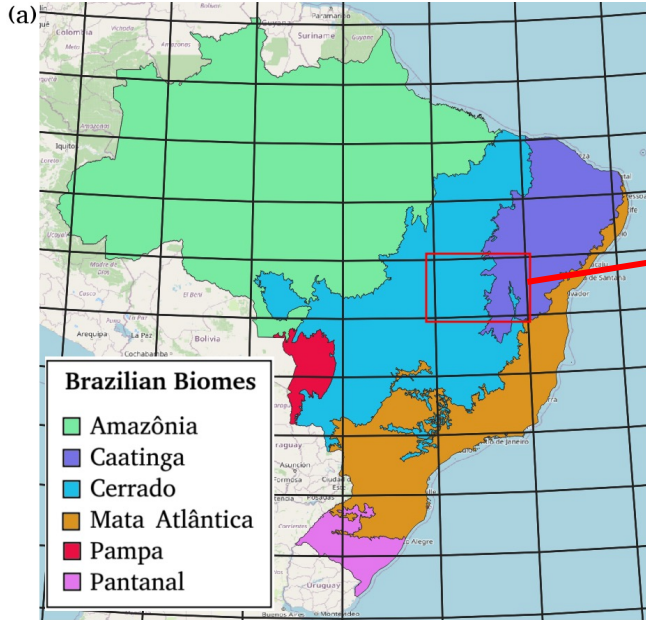


Source: [Ferreira et al., 2022]

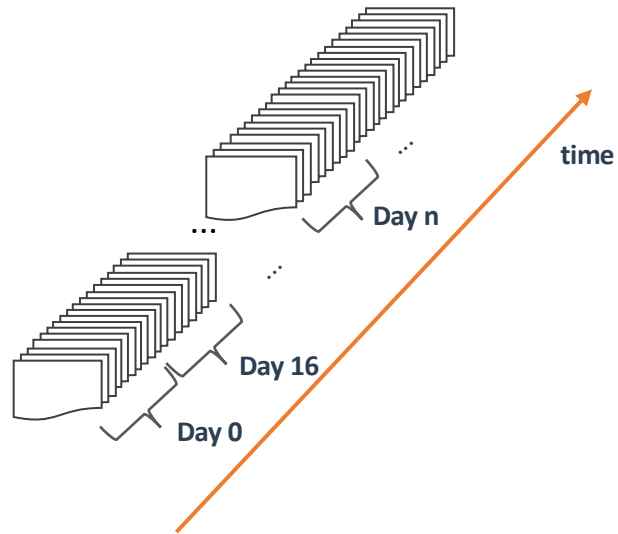


Building data cubes

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*bilinear resampling for better spatial resolution band



For each *tile* and *time step*, there are a set of COG (Cloud Optimized GeoTIFF) files:

- (1) Spectral bands from original images;
- (2) Vegetation indices (EVI and NDVI);
- (3) Cloud mask; (4) number of valid observations (excluding cloud, cloud shadow..); (5) data provenance; ...

brazildatacube.dpi.inpe.br/portal/explore

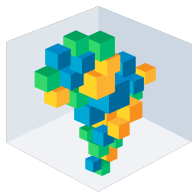


BDC – Small

Each tile: 105600m x 105600m

Sentinel-2/MSI – 10 meters
Each file (band/tile): 400 MB

Each tile: ~ 5.4 GB

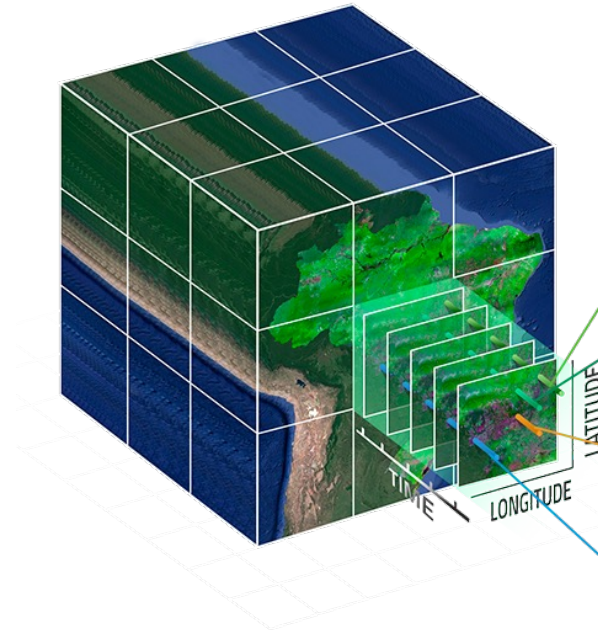


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Why Earth Observation (EO) Data Cubes ?

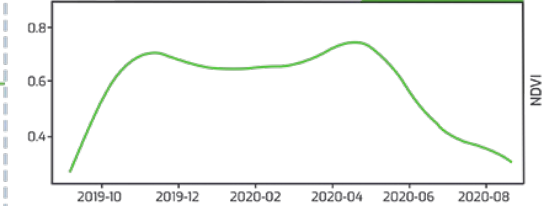
Multidimensional arrays of satellite images with four dimensions (latitude, longitude, time and attributes), mainly to support **image time series analysis**.

(Appel et al., 2019)

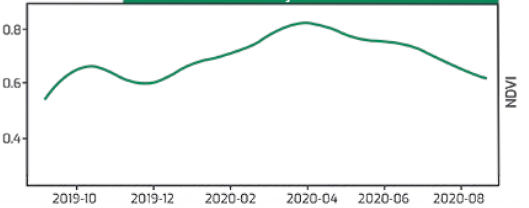


SÉRIES TEMPORAIS DE IMAGENS DE SATÉLITE

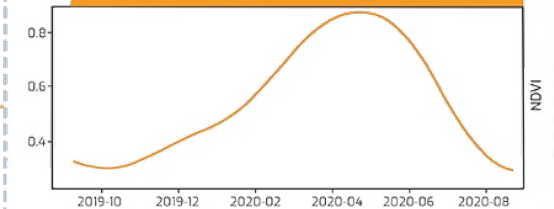
PASTAGEM



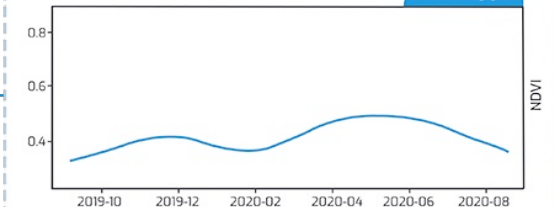
VEGETAÇÃO NATURAL PRIMÁRIA



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ÁGUA



Potential of image time series and machine learning

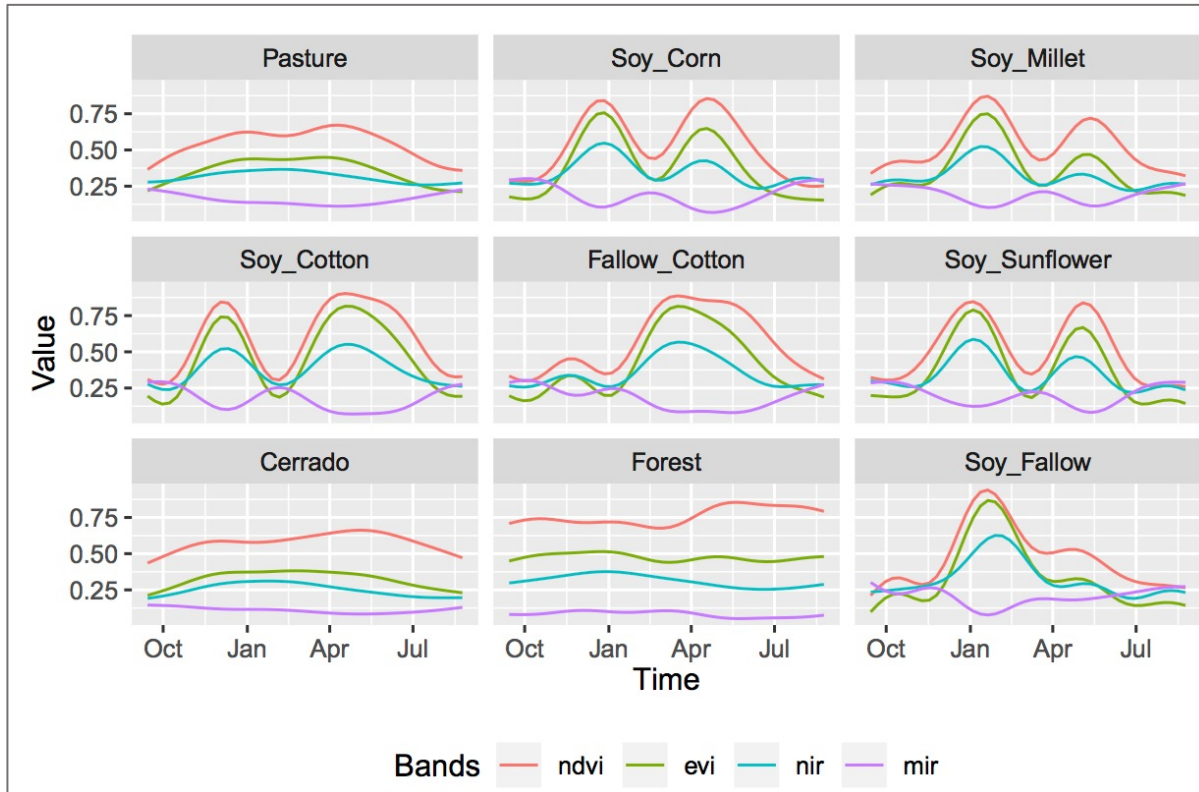
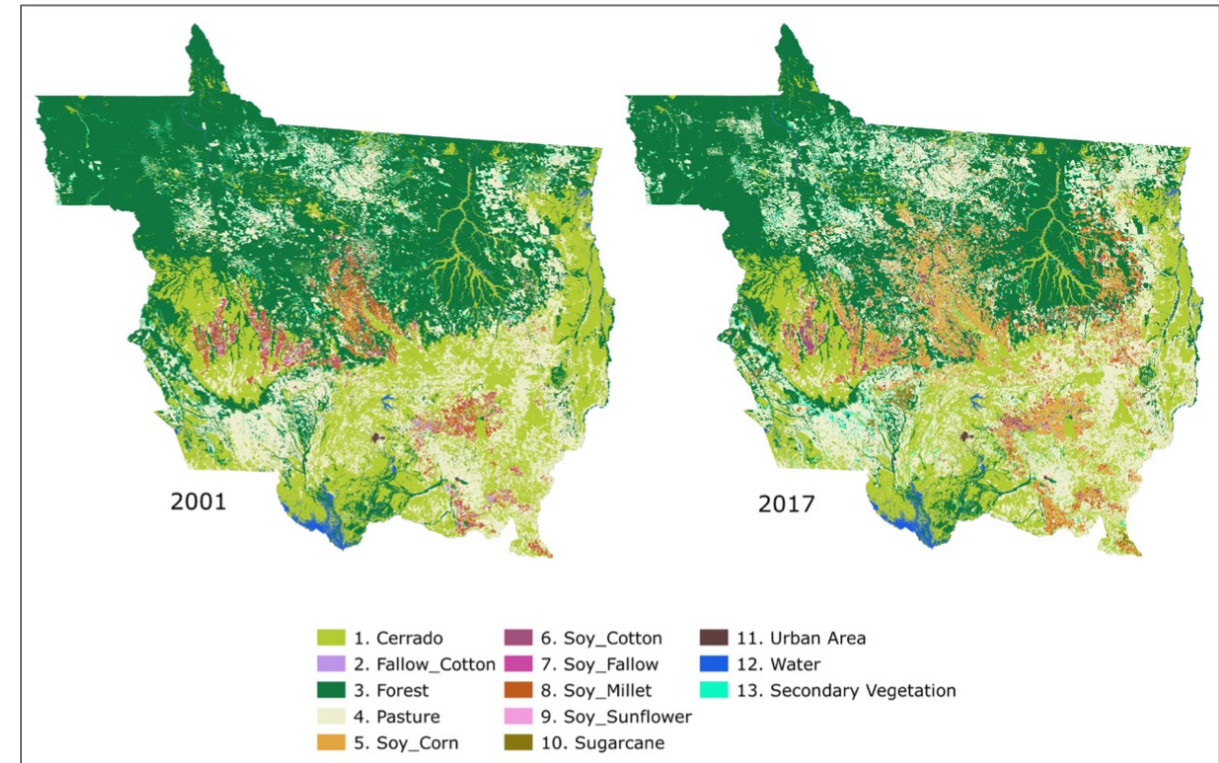


Image time series: NDVI, EVI, NIR, MIR (agriculture year)

MODIS (250 meters) – MOD13Q1 product

Method – SVM (Support Vector Machine)



Source: [Simoes et al., 2020]

Land use and cover maps for Mato Grosso State in Brazil from 2001 to 2017

Scientific Data, 2020



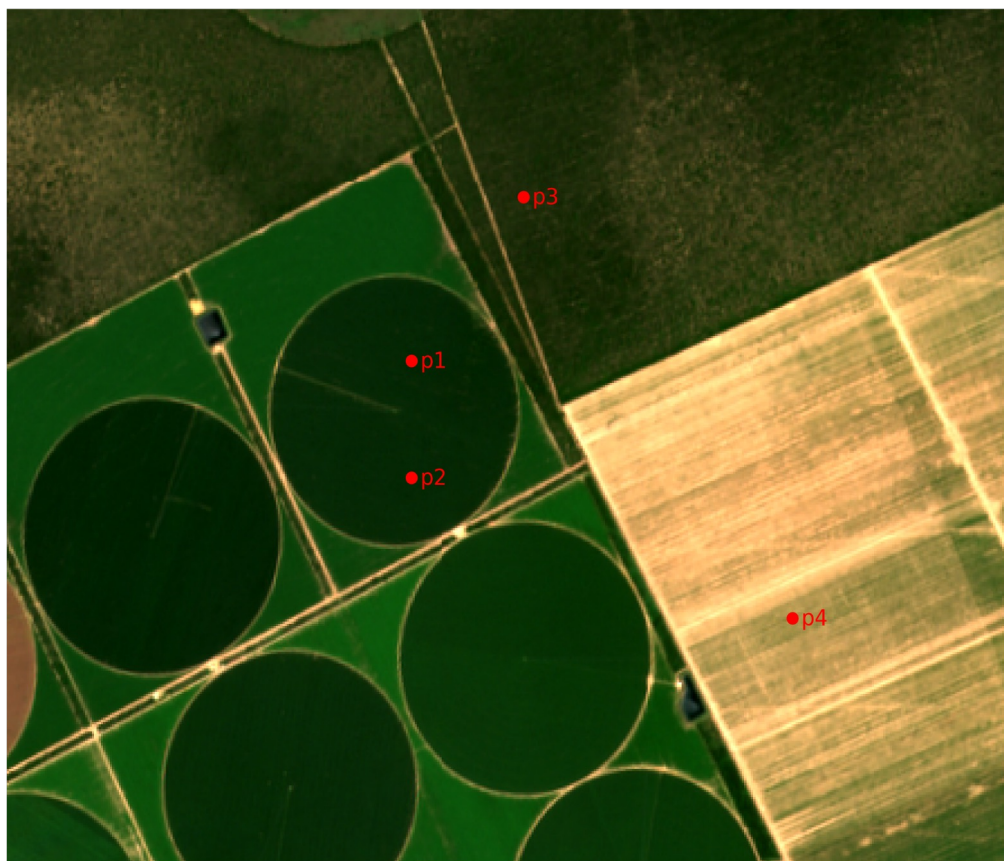
Satellite Image Time Series Analysis (SITS)

SITS reveal complex underlying processes that would be difficult to assess using bi-temporal or even annual change detection approaches.

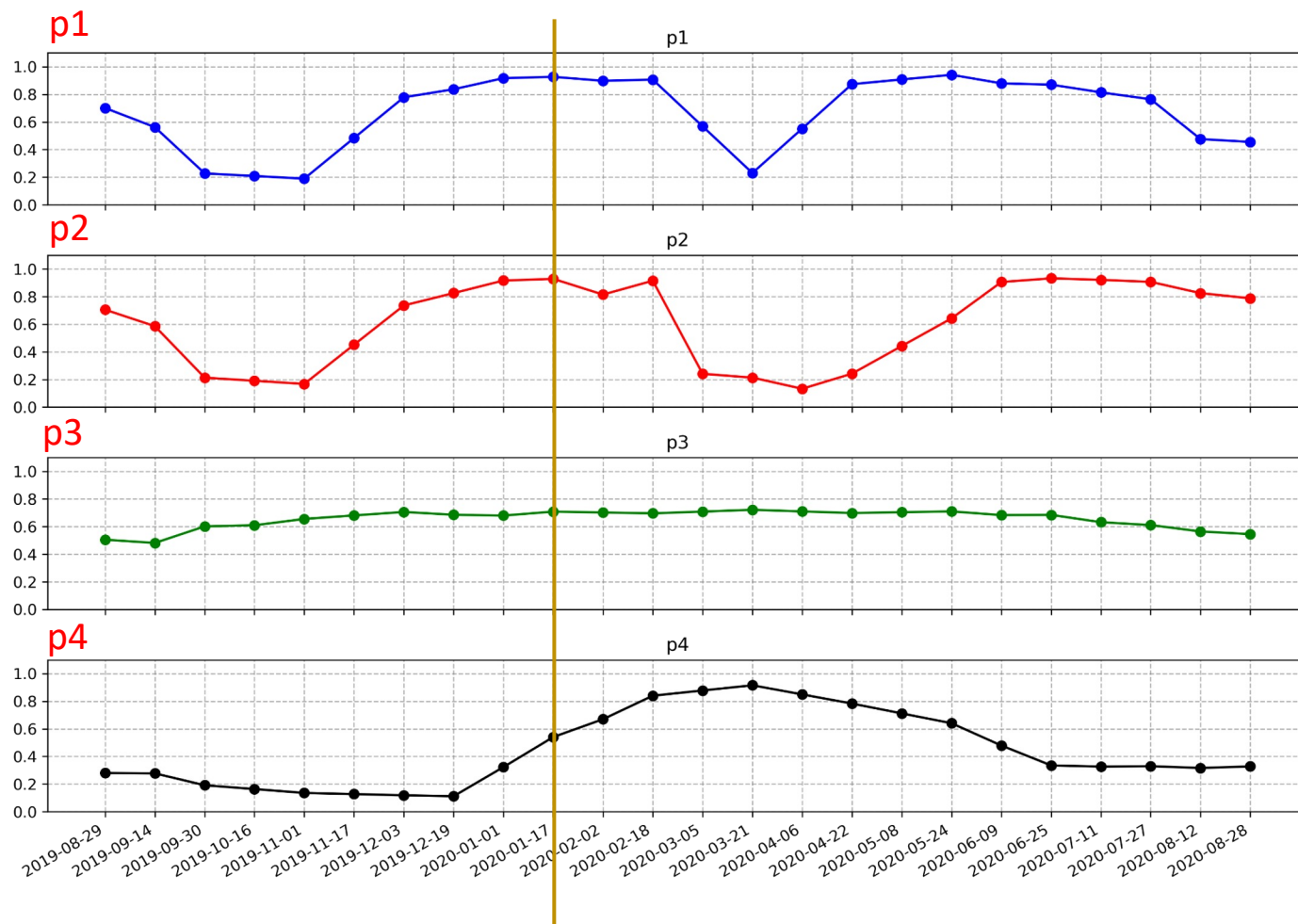
(Pasquarella et al., 2016)

NDVI Time Series – Sentinel-2 Data Cube (16-days)

Sentinel-2 RGB



2020-01-17

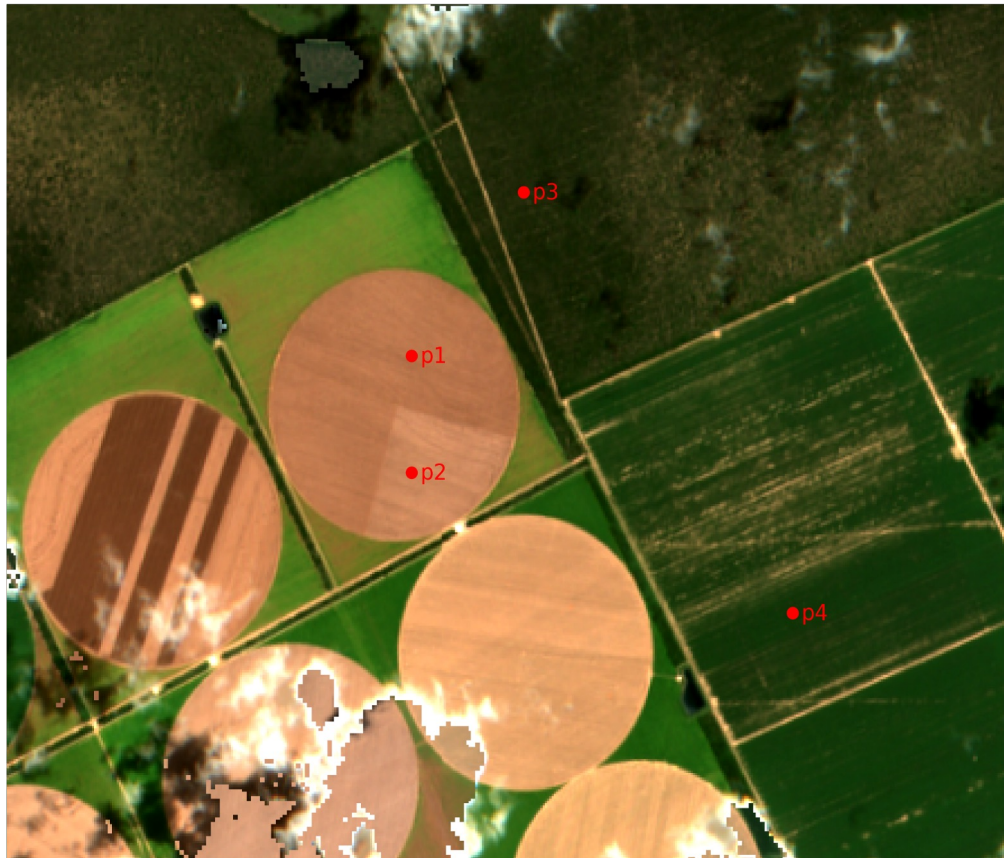


2020-01-17

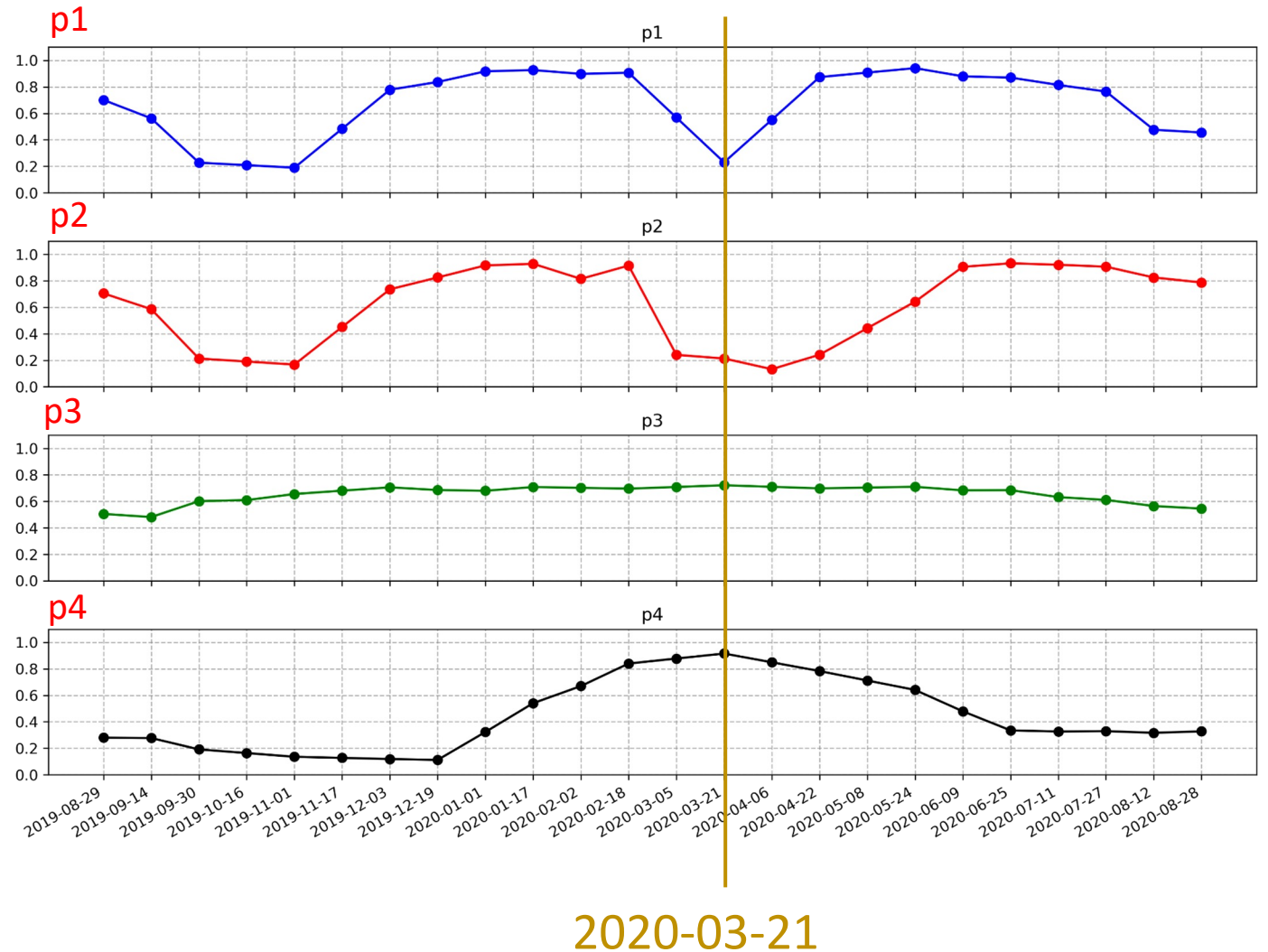


NDVI Time Series – Sentinel-2 Data Cube (16-days)

Sentinel-2 RGB



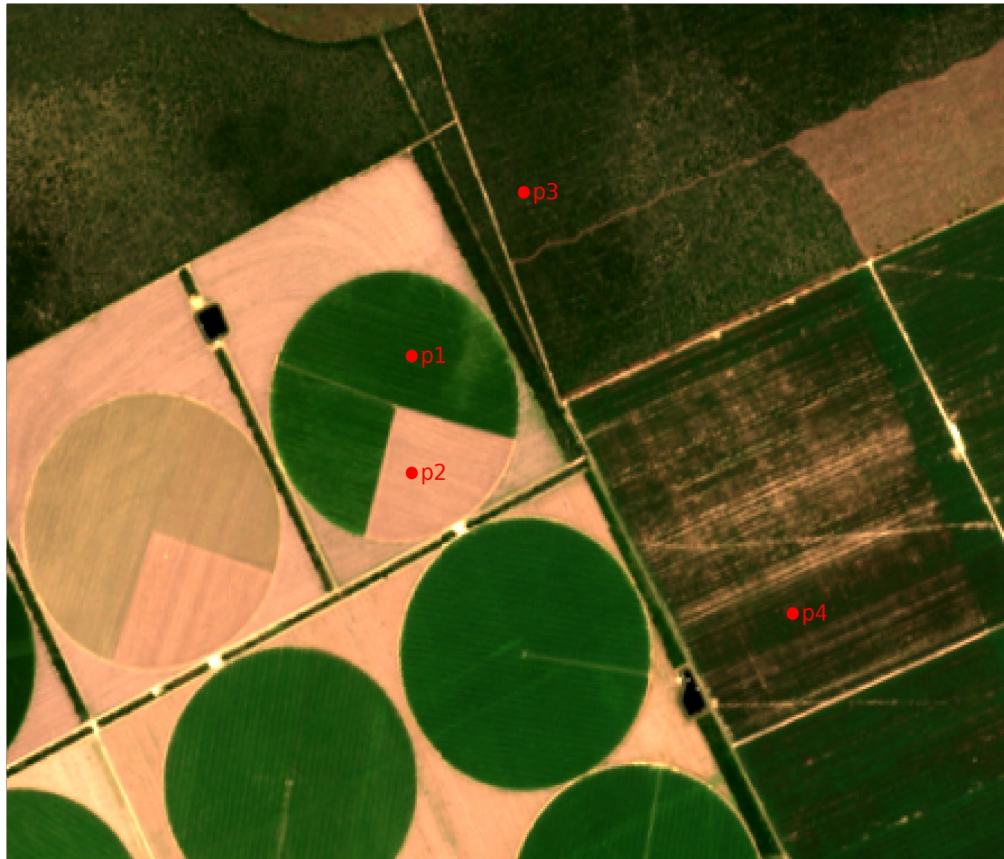
2020-03-21



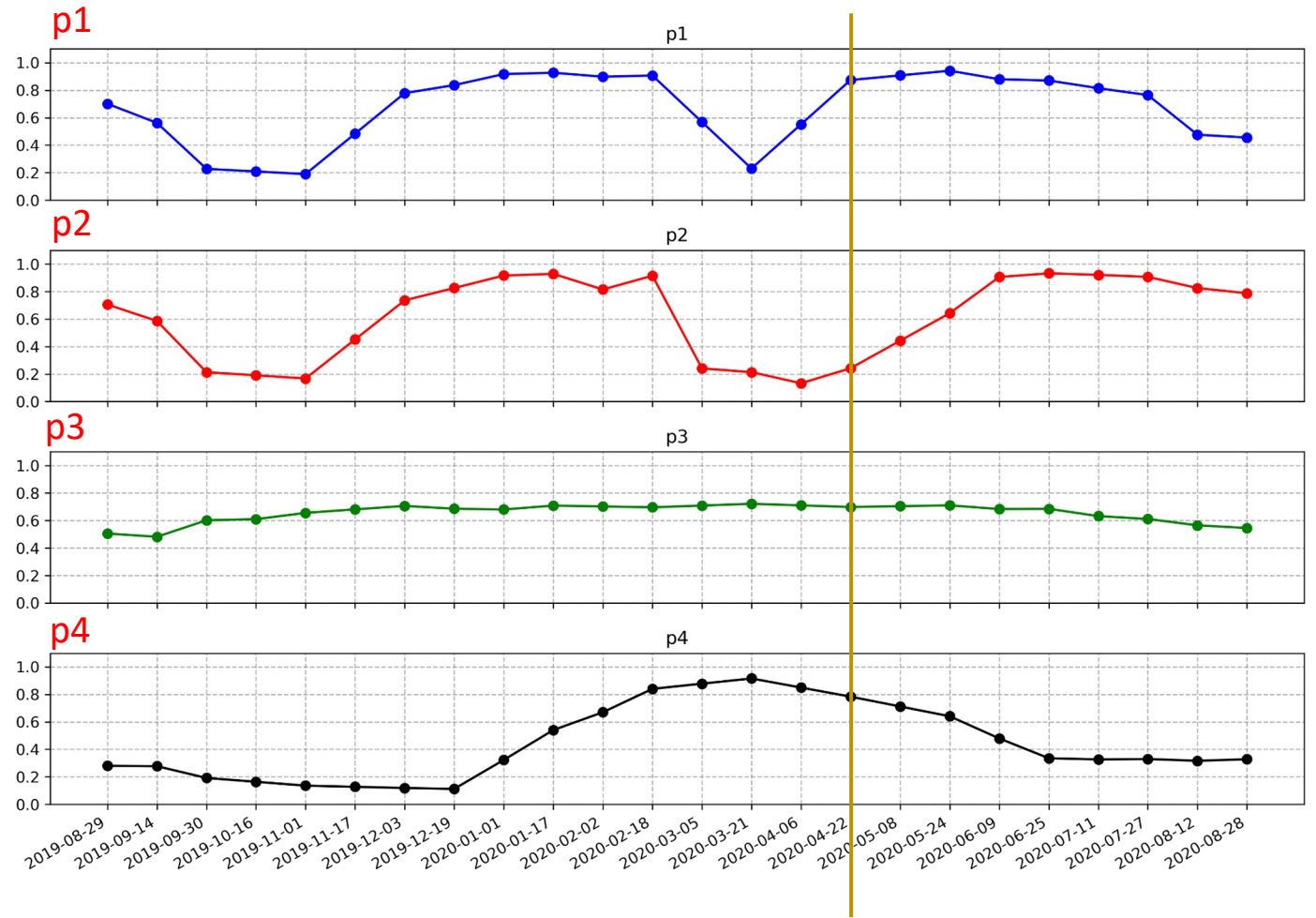


NDVI Time Series – Sentinel-2 Data Cube (16-days)

Sentinel-2 RGB



2020-04-22



2020-04-22

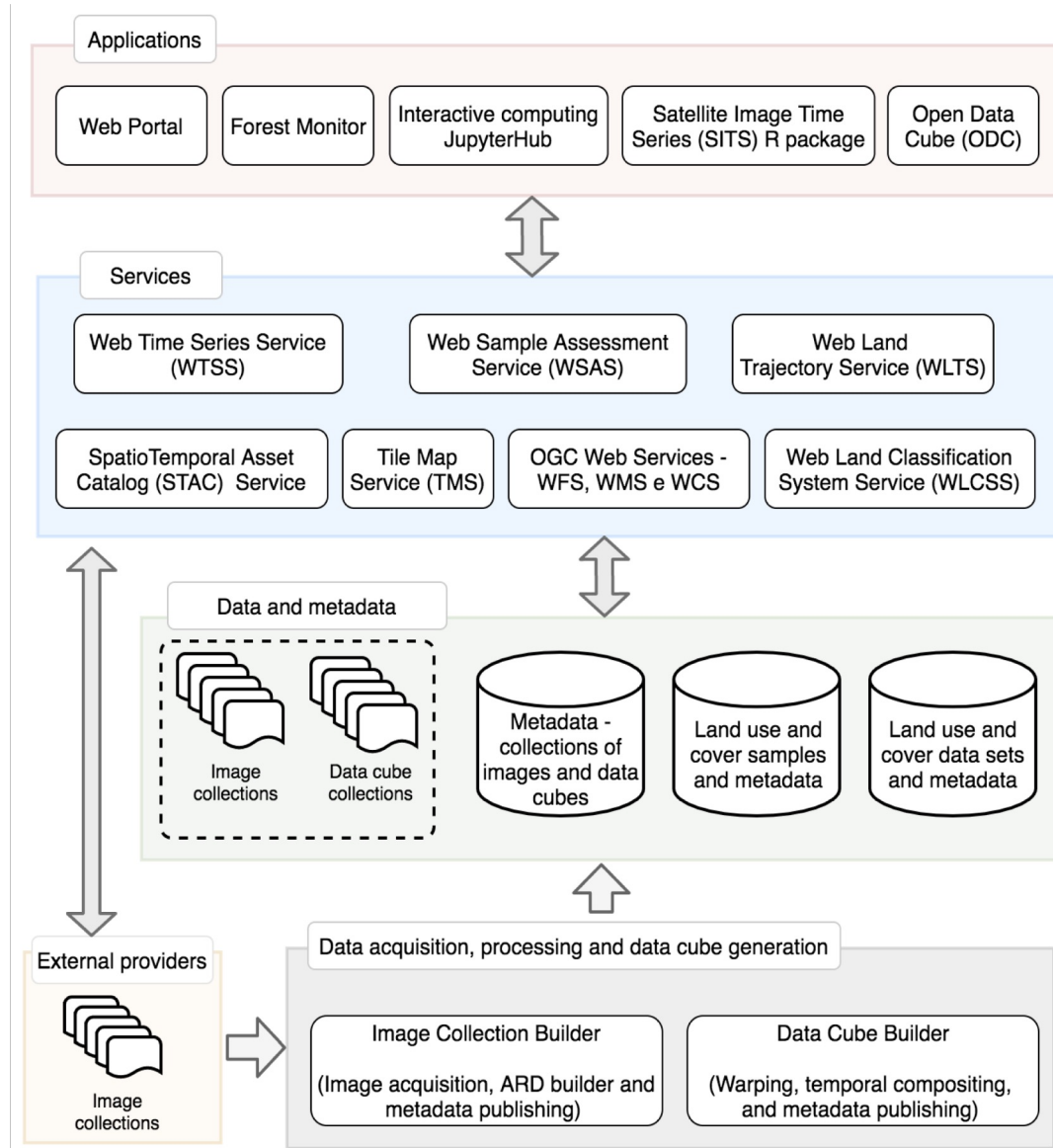


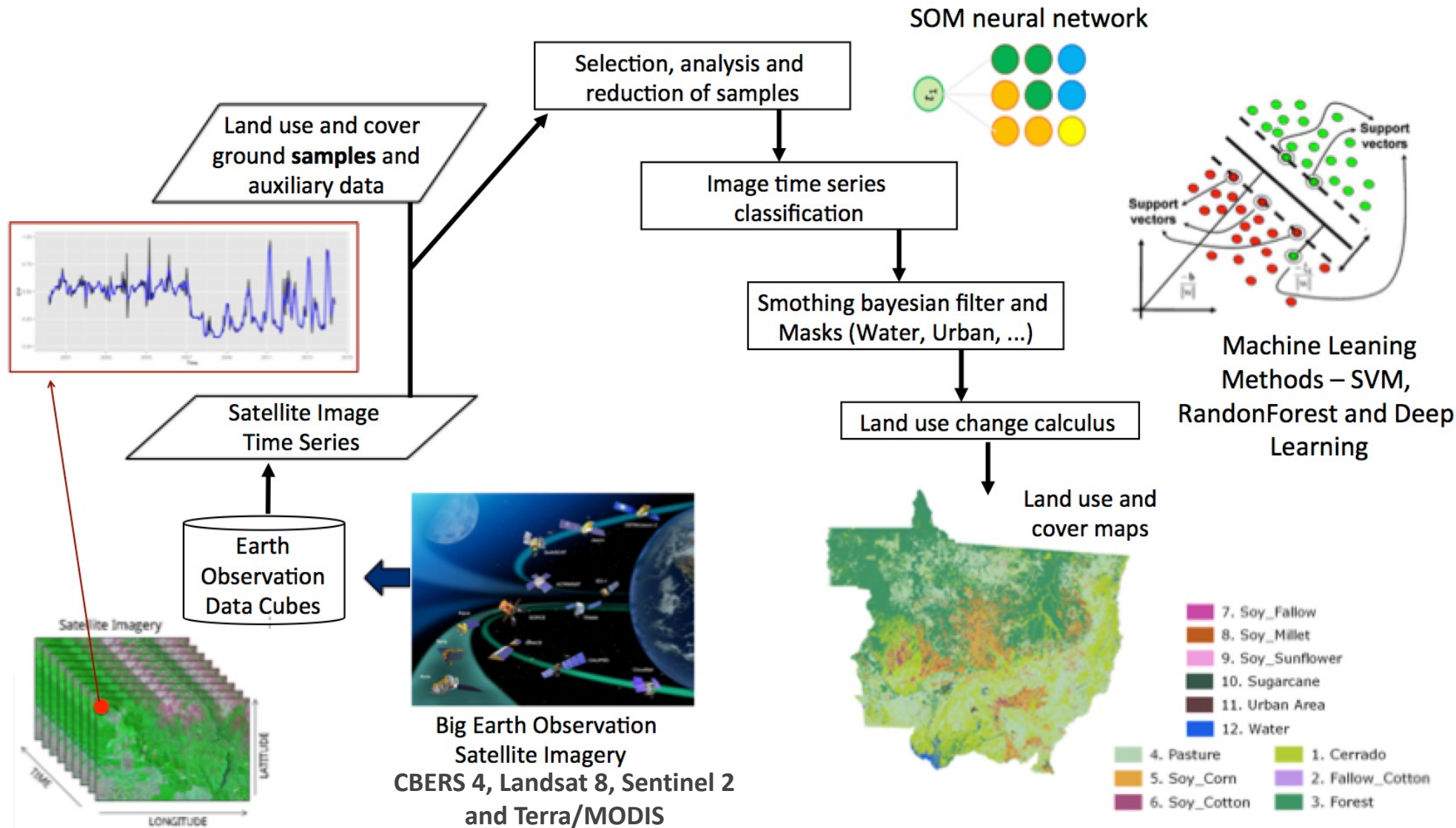
Brazil Data Cube Platform

Open
Data and
Software
Products

Software

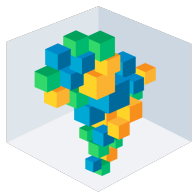
Data and
metadata





ARD and Data cubes available at:
<http://brazildatacube.dpi.inpe.br/portal/explore>

Land use and cover change maps:
<http://brazildatacube.dpi.inpe.br/portal/explore>



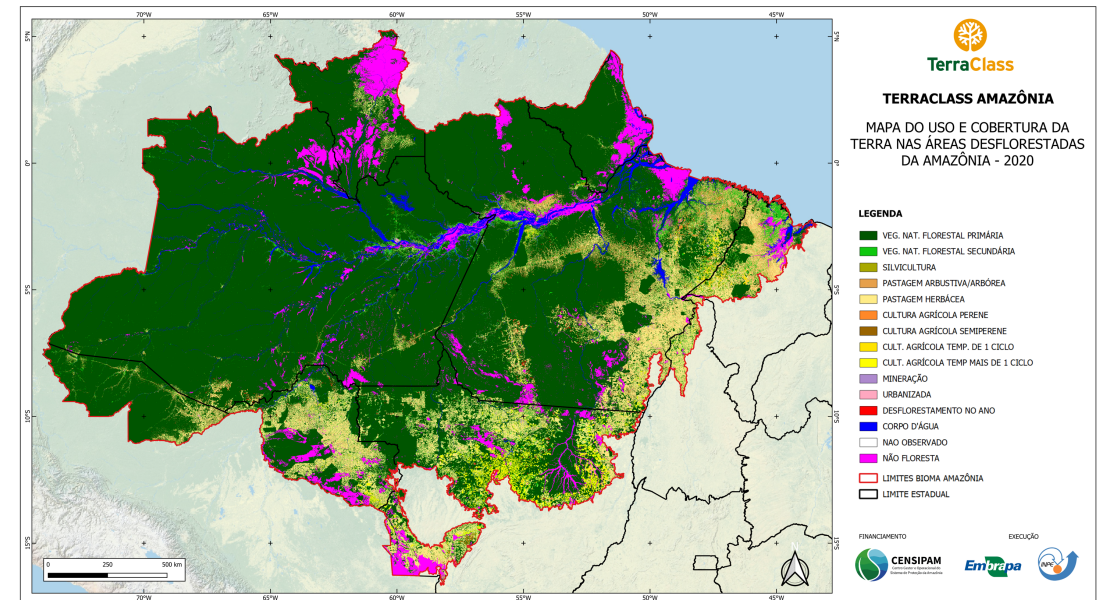
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Land use and land cover maps: TerraClass project

TerraClass Cerrado 2020 (Launched in December 2022)



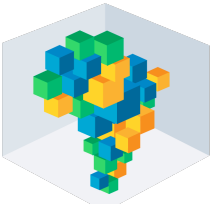
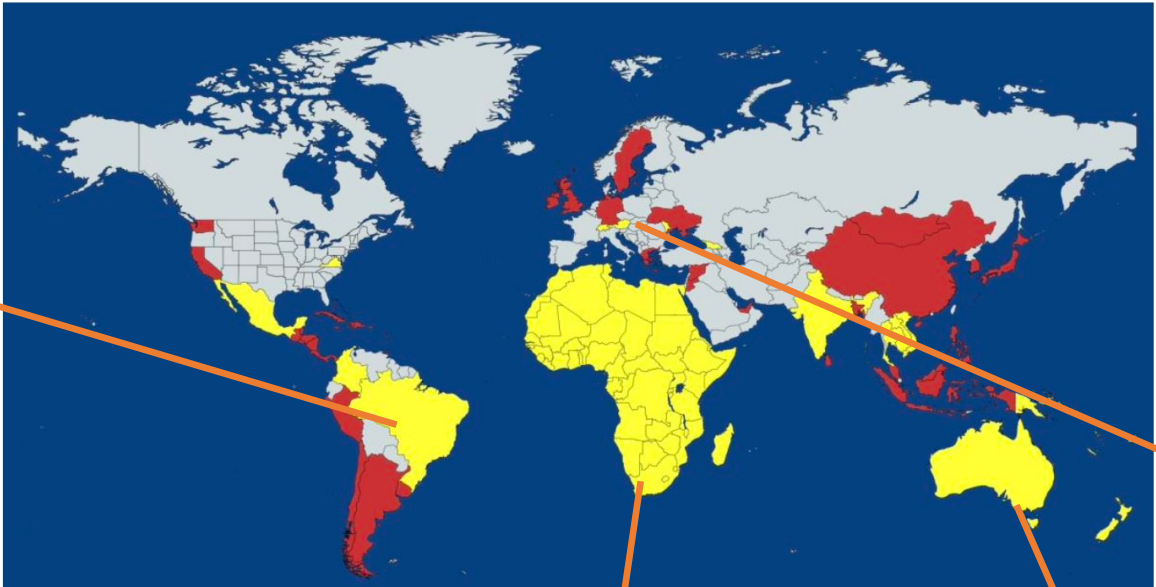
TerraClass Amazônia 2020



Partnership with international and similar initiatives

Source: [Sudmanns et al, 2022]

Yellow: operational
Red: under development



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<http://brazildatacube.org>

**data**

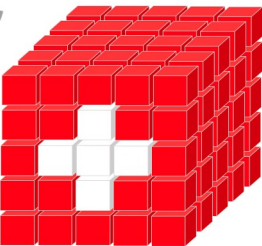


Article

Paving the Way towards an Armenian Data Cube



Swiss
Data
Cube



<https://www.swissdatacube.org/>



Digital Earth Americas

A vision for a solution that provides relevant Earth observation data for the benefit of the Americas



Digital Earth
AFRICA

<https://digitalearthafrika.org/>



Digital Earth
AUSTRALIA

<https://www.dea.ga.gov.au/>

<http://brazildatacube.org>

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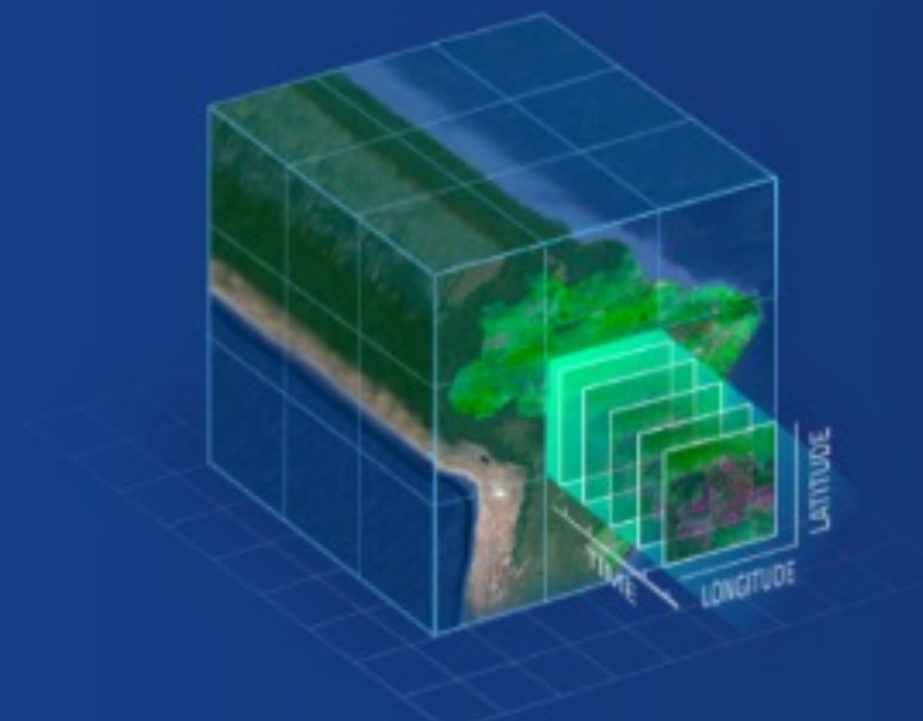
Search ... 



Brazil Data Cube

Production, visualization and analysis of large volumes of remote sensing images modeled as multidimensional data cubes for the entire Brazilian territory.

[Read more](#)





Code Galery

<http://brazildatacube.org>

README.md

Brazil Data Cube Code Gallery

license

MIT

lifecycle

medium

render

intobrowser

chat

18 online

This repository contains a gallery of interesting Jupyter Notebooks, R Markdown and scripts based on Brazil Data Cube data and technologies.

Jupyter Notebooks

Data Access through SpatioTemporal Asset Catalog API (STAC)

- Introduction to the SpatioTemporal Asset Catalog. (Python, R)
- Image processing on images obtained through STAC.

Web Time Series Service (WTSS)

- Introduction to the Web Time Series Service (WTSS). (Python, R).
- Web Time Series Service (WTSS) examples. (Python, R).

Web Land Trajectory Service (WLTS)

- Introduction to the Web Land Trajectory Service (WLTS). (Python, R)
- Web Land Trajectory Service (WLTS) examples. (Python).

Tile Map Service (BDC-Tiler)

- Introduction to the Tile Map Service (BDC-Tiler). (Python)

Packages

No packages published

Contributors 7

Languages

Jupyter Notebook 96.2%

R 3.8%

sbsr2023-wtss-examples
Updated 2d ago
0 comments · No attached data sources

sbsr2023-wtss-introduction
Updated 2d ago
0 comments · No attached data sources

sbsr2023-wtss2
Updated 12d ago
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sbsr2023-sample-quality-control-using-som
Updated 12d ago
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sbsr2023-machine-learning-for-data-cubes
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sbsr2023-image-classification-in-data-cubes
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sbsr2023-working-with-time-series-in-sits
Updated 12d ago
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+

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Brazil Data Cube
Earth Observation Data Cubes for Brazil at National Institute for S...
São José dos Campos, State of São Paulo, Brazil
Joined 2 years ago · last seen 2 days ago

Python

Comments (0)

workshop-2021-03-wtss-introduction-python

File Edit View Run Add-ons Help

+ - X Copy Paste Run All Code

[6]

Coverage S2-SEN2COR_10_16D_STK-1

Description: This datacube was generated with all available surface reflectance images processed using Sen2cor (illumination correction and cloud masking) and then aggregated using the temporal compositing function of 16 days using the best pixel approach (Stack).

item = collection.get_items(filters={'bbox': '-65.0, -10.32, -63.8, -10.37', 'datetime': '2018-07-01/2019-08-31', 'limit': '2'})

item

Matched: 12 Returned: 2 Limit: 2

S2-SEN2COR_10_16D_STK_v001_077095_2018-12-19_2018-12-31

S2-SEN2COR_10_16D_STK_v001_077095_2018-12-19_2018-12-31

Collection: S2-SEN2COR_10_16D_STK-1

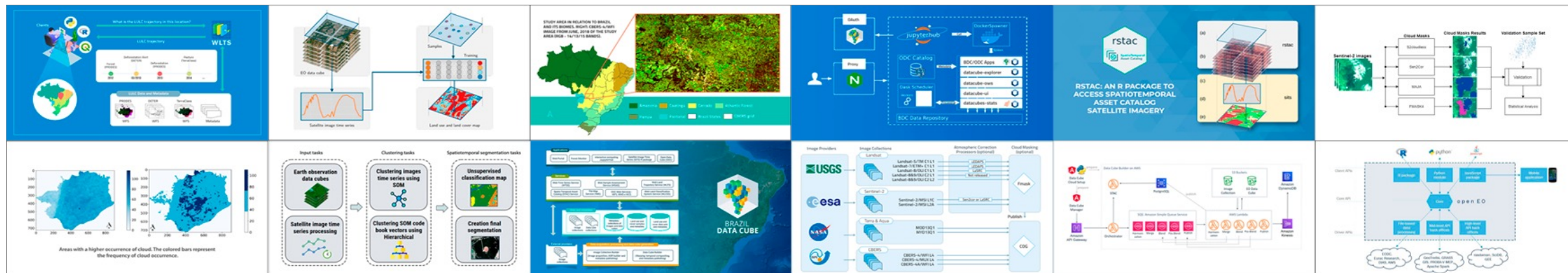
Datetime: 2018-12-19T00:00:00

STAC Version: 0.9.0

Thumbnail

Bands

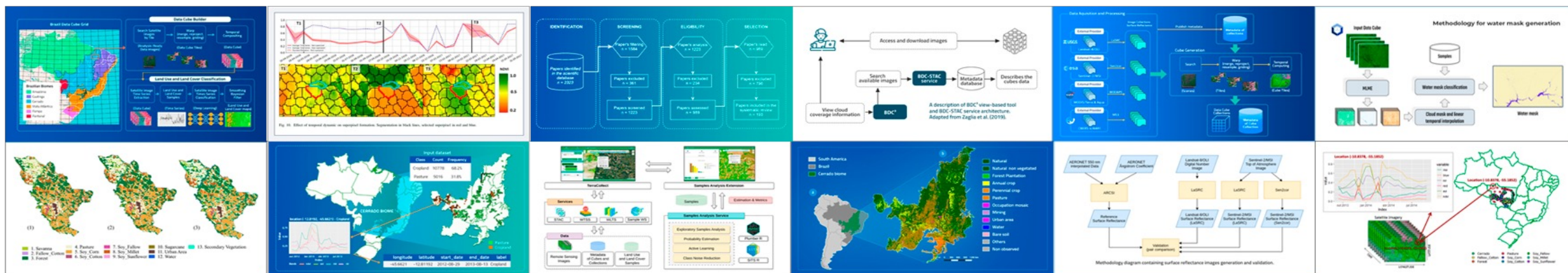
name	common_name	min	max	nodata	scale	data_type
B03	green	0.0	10000.0	-9999.0	0.0001	int16
B06	rededge	0.0	10000.0	-9999.0	0.0001	int16
B07	rededge	0.0	10000.0	-9999.0	0.0001	int16
B08	nir	0.0	10000.0	-9999.0	0.0001	int16
B09	nir09	0.0	10000.0	-9999.0	0.0001	int16
B8A	nir08	0.0	10000.0	-9999.0	0.0001	int16



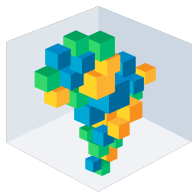
50 PUBLICAÇÕES

29 – Revistas e eventos internacionais

21 – Revistas e eventos nacionais

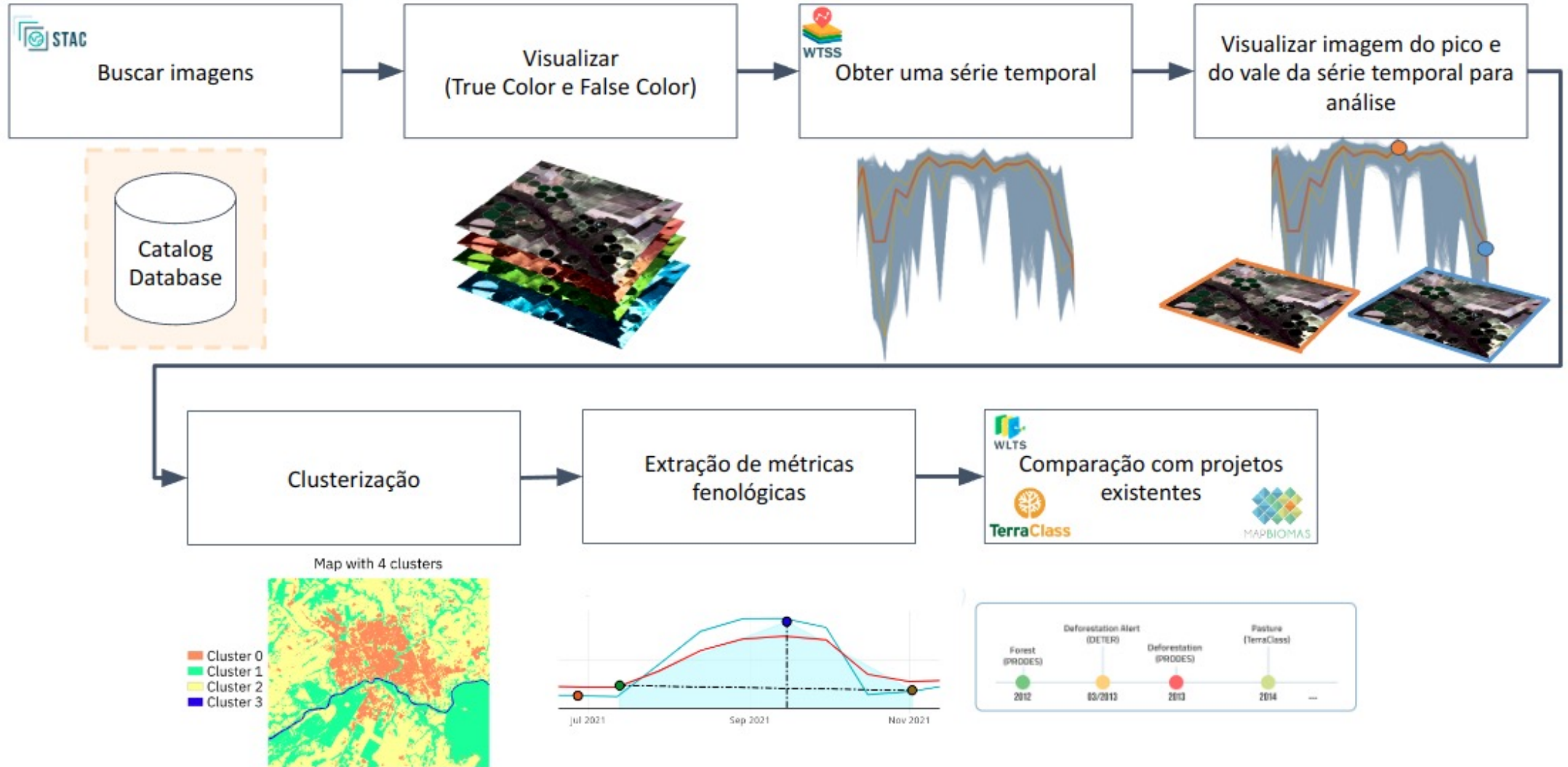


<http://brazildatacube.org>



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SBSR 2025 - Course



Interoperabilidade



Google Earth Engine



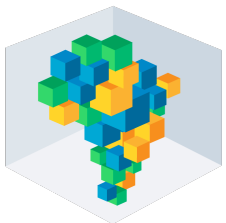
Microsoft



Planetary Computer

Copernicus Data

Space Ecosystem (CDSE)



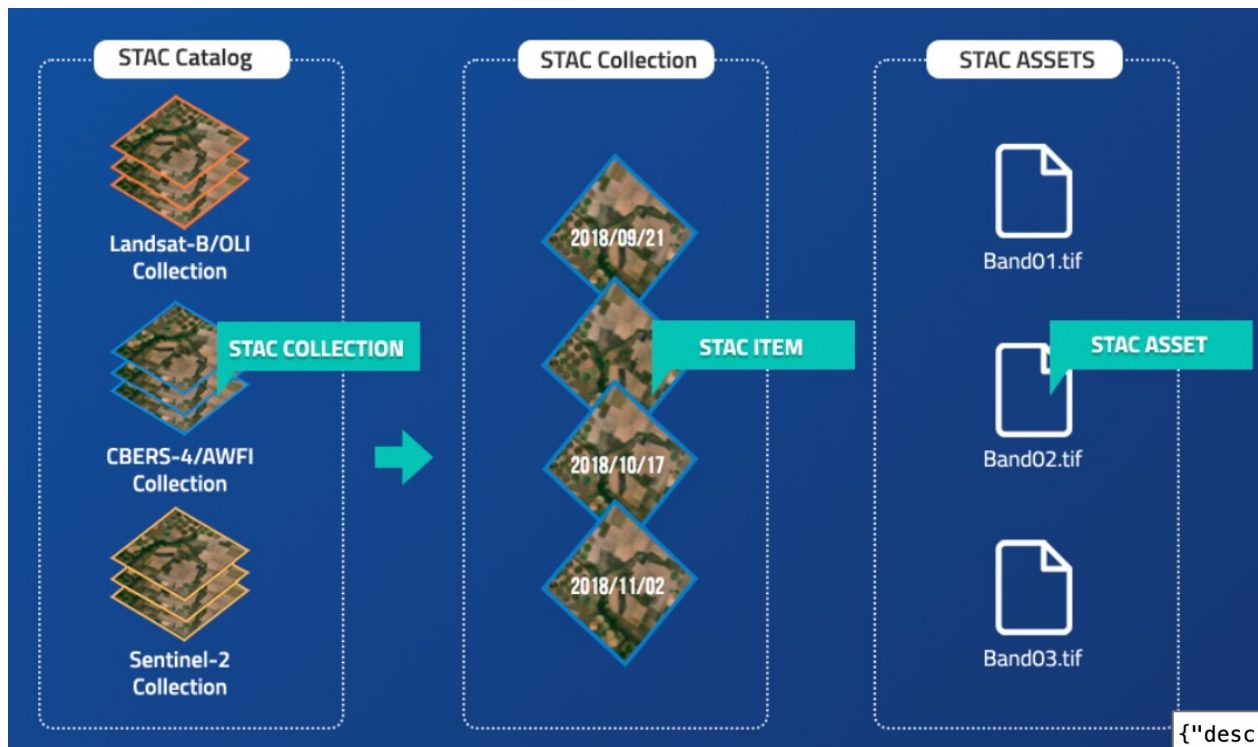
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SpatioTemporal Asset Catalog

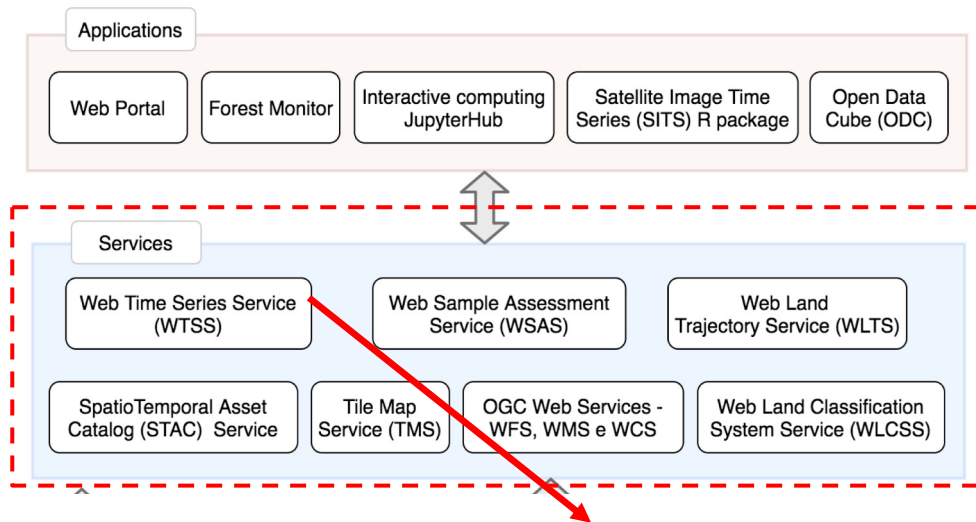
Especificação que define uma estrutura comum, em arquivos JSON e GEOJSON, para descrever e catalogar dados geográficos.

Source: <https://stacspec.org/en>

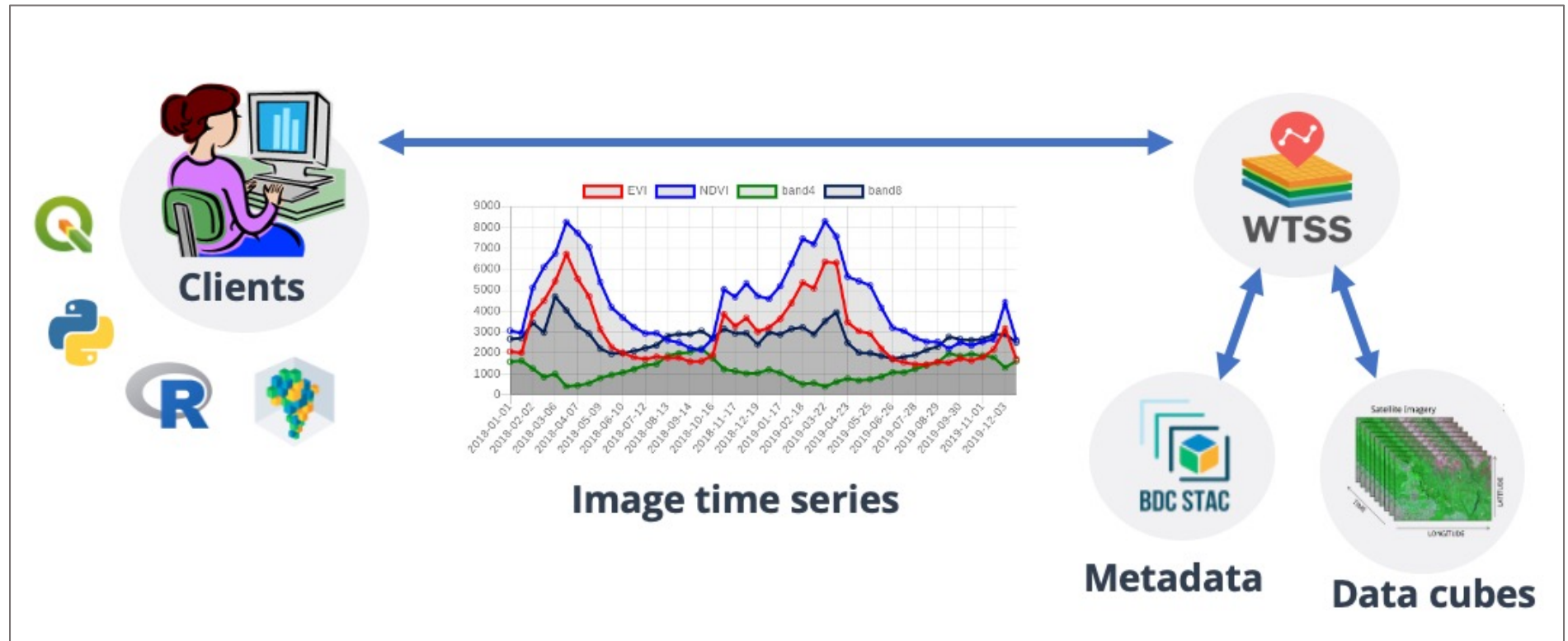


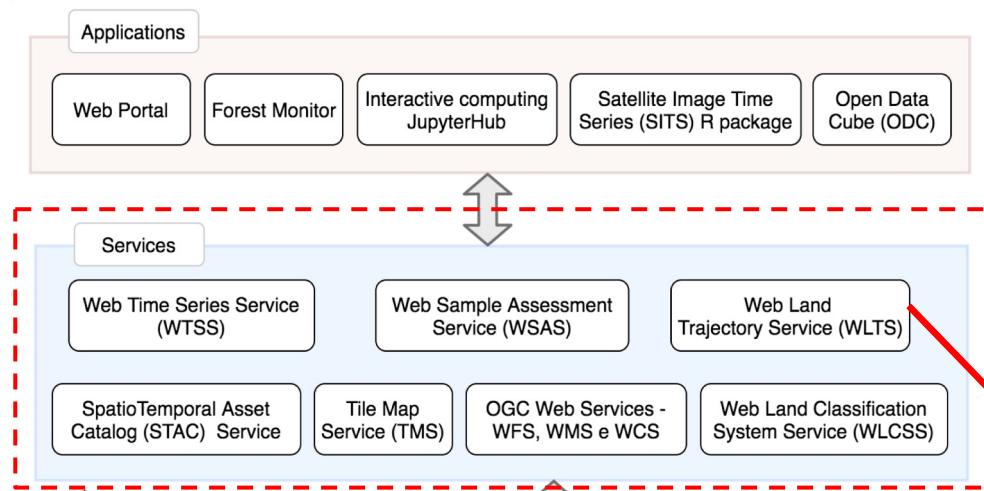
```
{
  "description": "Brazil Data Cube Catalog",
  "id": "bdc",
  "stac_version": "0.9.0",
  "links": [
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/",
      "rel": "self",
      "type": "application/json",
      "title": "Link to this document"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/docs",
      "rel": "service-doc",
      "type": "text/html",
      "title": "API documentation in HTML"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/conformance",
      "rel": "conformance",
      "type": "application/json",
      "title": "OGC API conformance classes implemented by the server"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections",
      "rel": "data",
      "type": "application/json",
      "title": "Information about image collections"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/search",
      "rel": "search",
      "type": "application/json",
      "title": "STAC-Search endpoint"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/MOSAIC-S2-YANOMAMI-6M-1",
      "rel": "child",
      "type": "application/json",
      "title": "Sentinel-2 - Yanomami - Mosaic"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/CB4-MOSAIC-BRAZIL_64_3M_STK-1",
      "rel": "child",
      "type": "application/json",
      "title": "CBERS-4 - Brazil - Mosaic"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/MYD13Q1-6",
      "rel": "child",
      "type": "application/json",
      "title": "MYD13Q1 C6"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/MOD13Q1-6",
      "rel": "child",
      "type": "application/json",
      "title": "MOD13Q1 C6"
    },
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      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/LANDSAT-MOZ_30_1M_STK-1",
      "rel": "child",
      "type": "application/json",
      "title": "Landsat - Mozambique - Monthly"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/LCC_L8_30_16D_STK_Amazonia-TC-1",
      "rel": "child",
      "type": "application/json",
      "title": "LCC Landsat-8 16D STK Amazonia-Terra Class"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/LCC_S2_10_1M_STK_PA-SPC-AC-NA-1",
      "rel": "child",
      "type": "application/json",
      "title": "LCC - Bahia - S2_10_1M_STK-1"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/CB4A-MOSAIC-PARAIBA_55_3M_STK-1",
      "rel": "child",
      "type": "application/json",
      "title": "CBERS-4A - Paraiba - Mosaic"
    },
    {
      "href": "https://brazildatacube.dpi.inpe.br/stac/collections/S2-MOSAIC-PARAIBA_10_3M_STK-"
    }
  ]
}
```

Source: <https://brazildatacube.dpi.inpe.br/stac/>

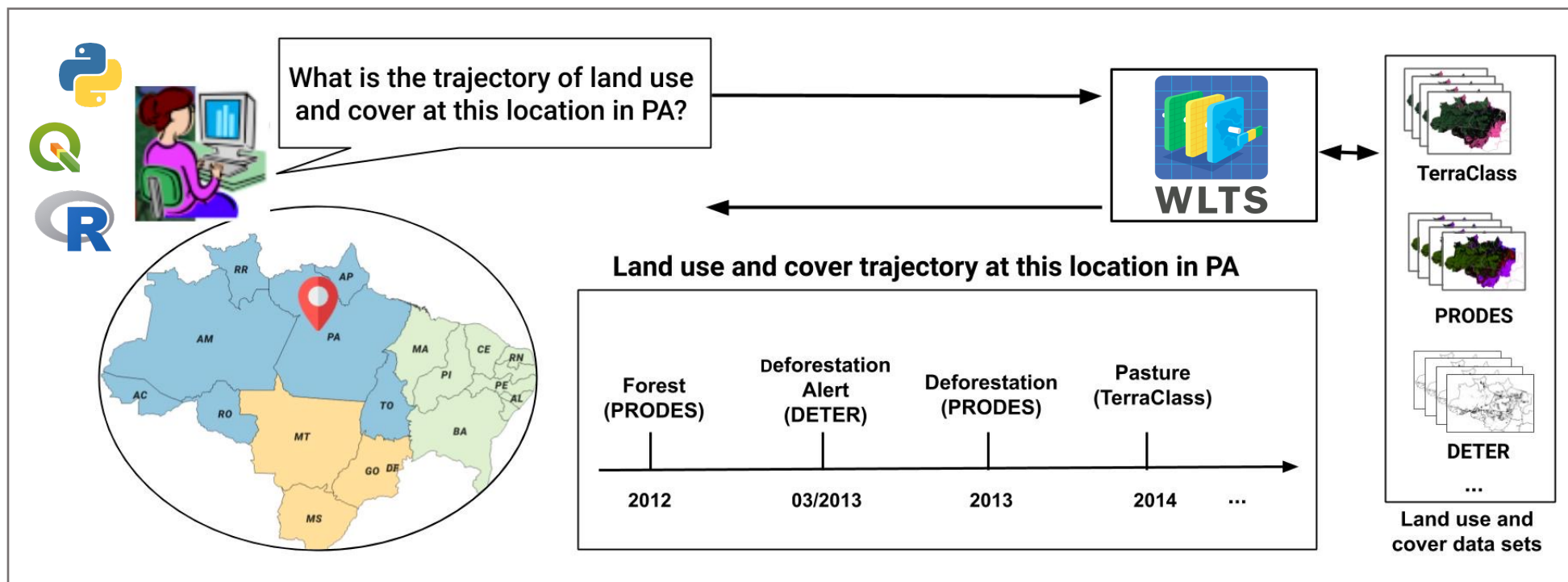


WTSS – Web Time Series Service

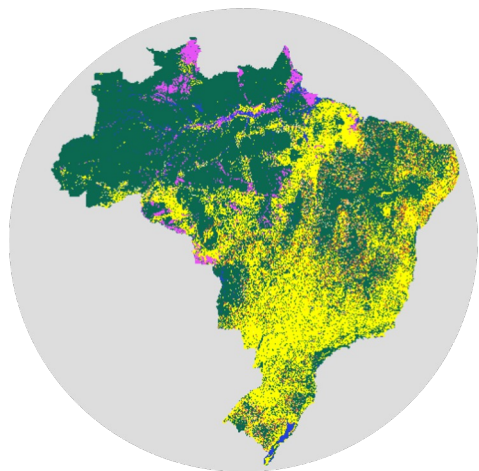




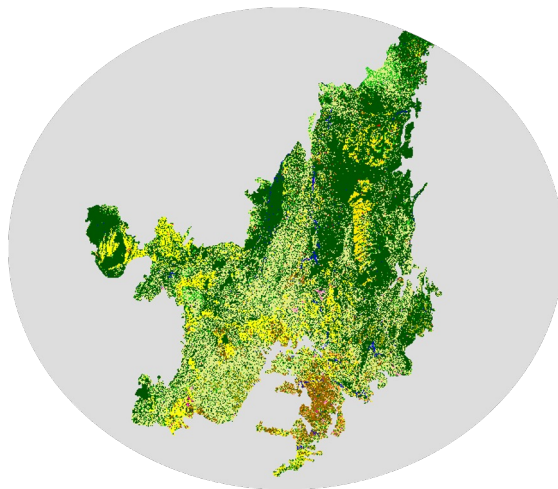
WLTS – Web Land Trajectory Service



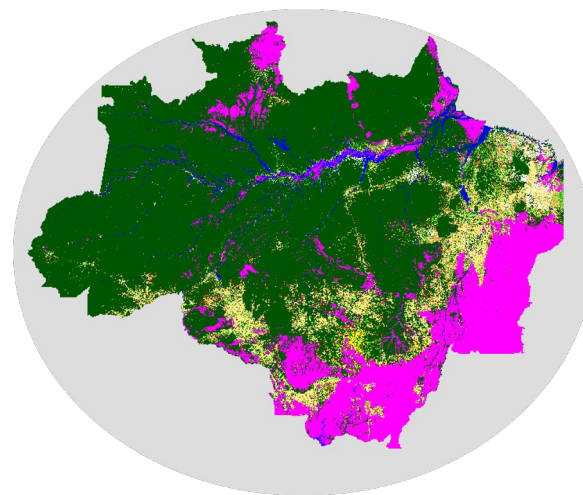
WLTS - Coleções



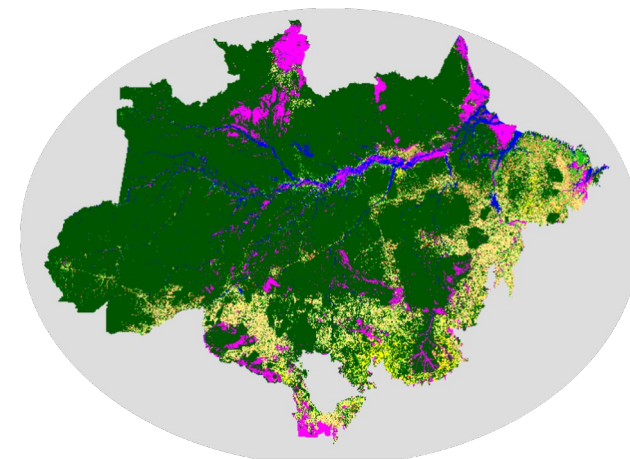
PRODES - Brasil
2007 - 2022
<http://terrabrasilis.dpi.inpe.br/>



TerraClass - Cerrado
2018 and 2020
<https://www.terraclass.gov.br/>



TerraClass - Amazônia
2004, 2008, 2010, 2012, 2014
<https://www.terraclass.gov.br/geoportais-aml/>



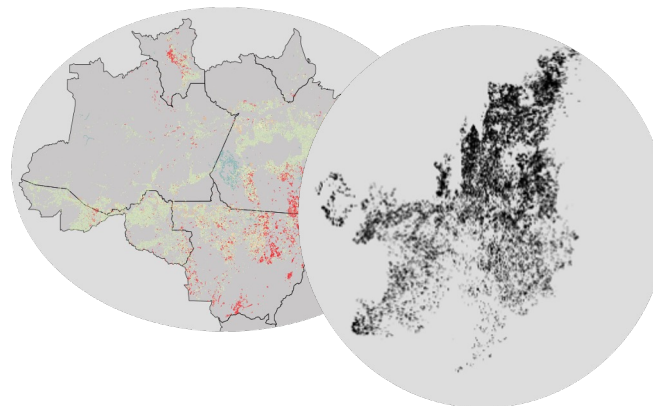
TerraClass - Amazônia
2020
<http://terrabrasilis.dpi.inpe.br/>



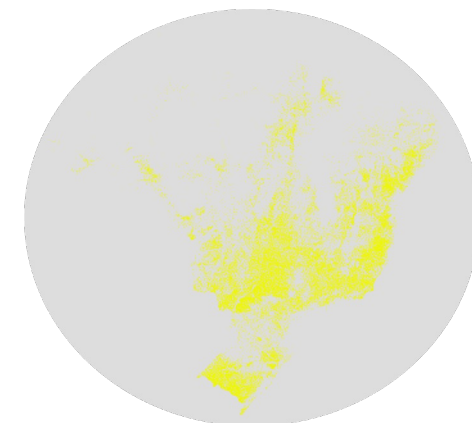
MapBiomas 8.0 - Brasil
1985 - 2022
<https://mapbiomas.org/>



IBGE LULC - Brasil
2000, 2010, 2012, 2014, 2016, 2018
<https://www.ibge.gov.br/>

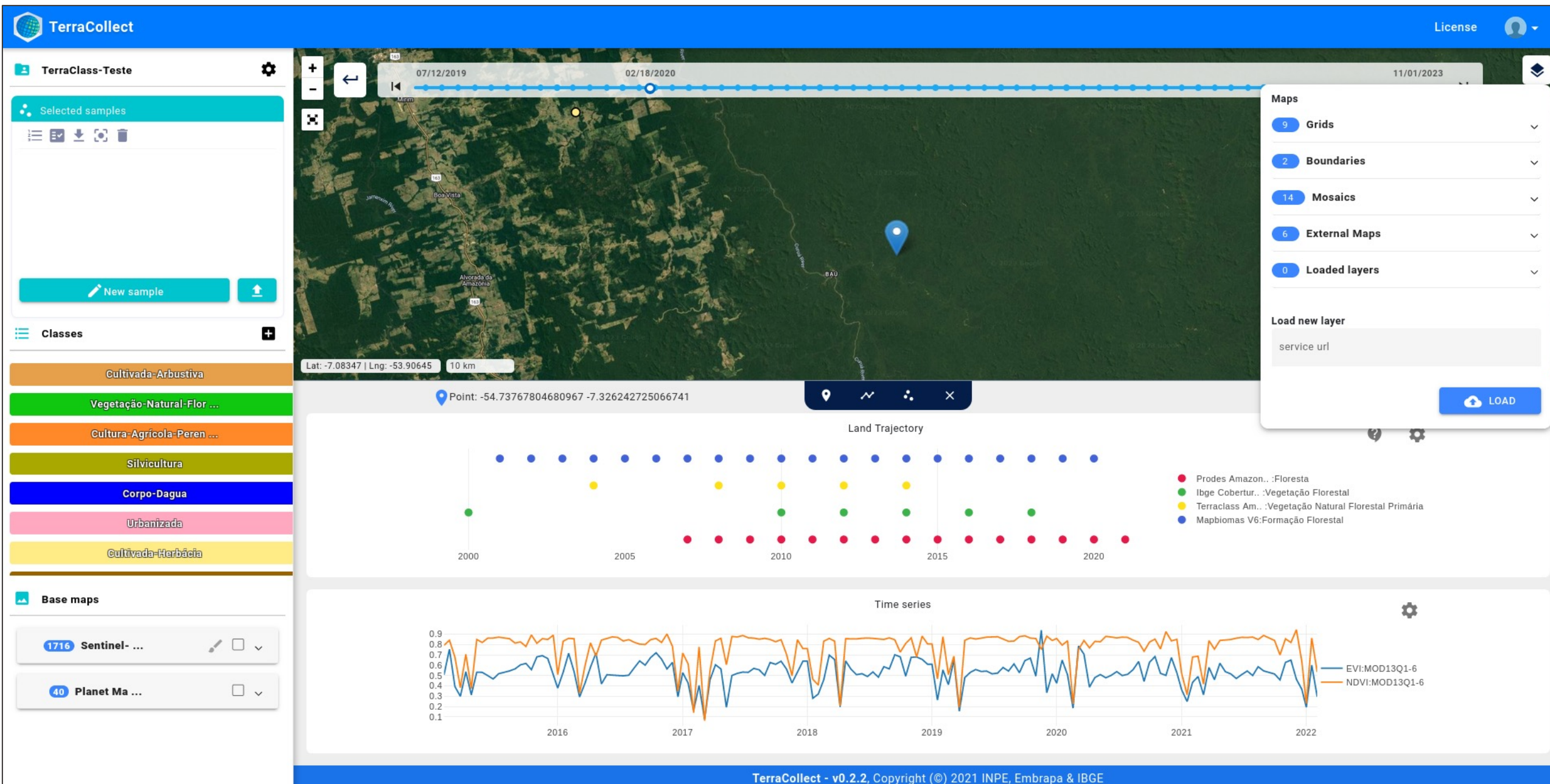


DETER - Amazônia e Cerrado
2018 - 2022
<http://terrabrasilis.dpi.inpe.br/>

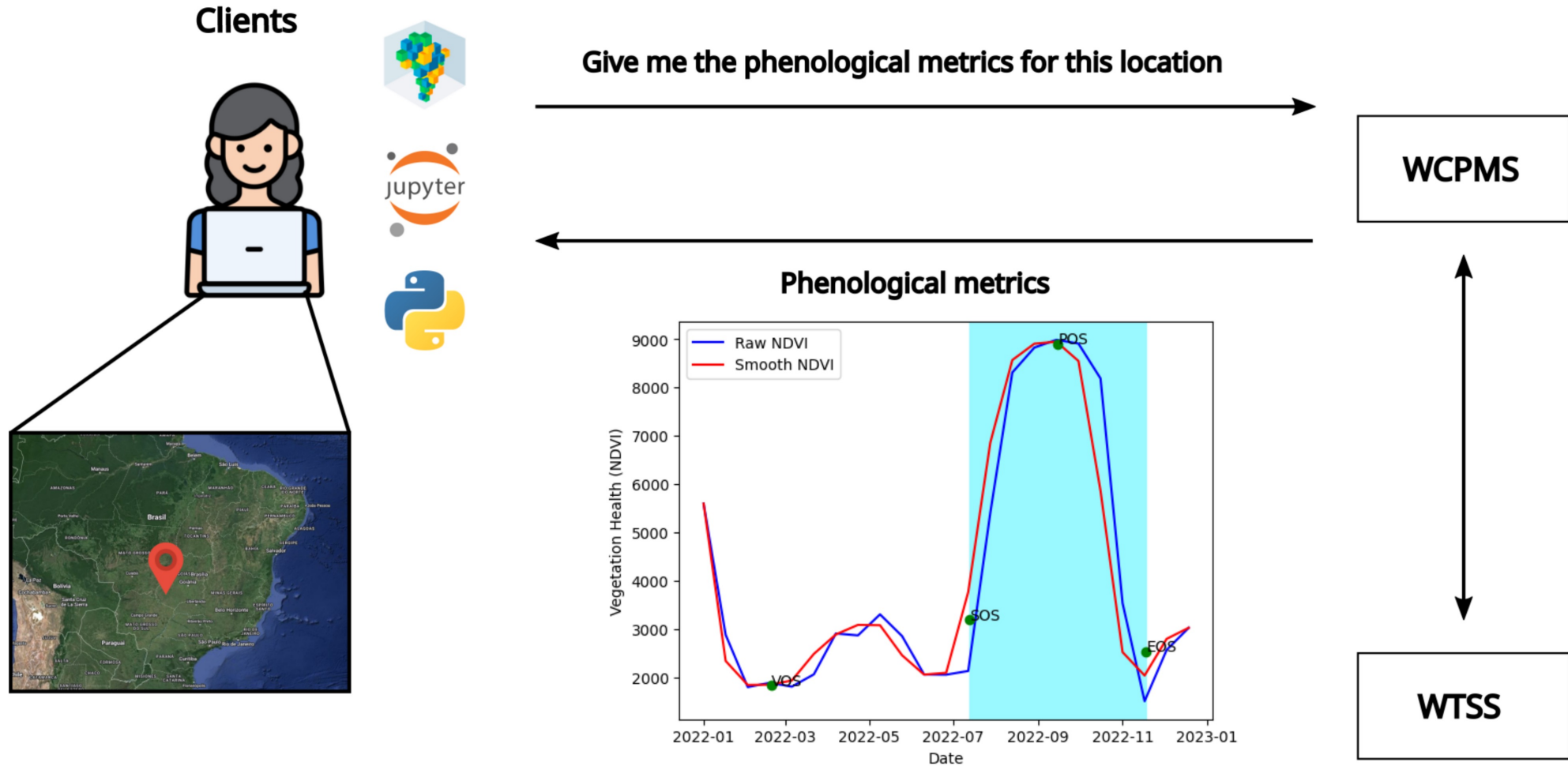


Lapig Pastagem - Brasil
1985 - 2021
<https://atlasdaspastagens.ufg.br/map>

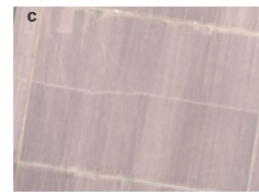
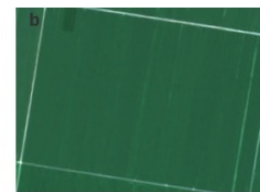
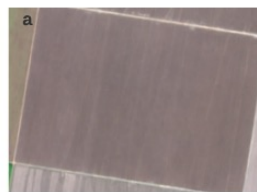
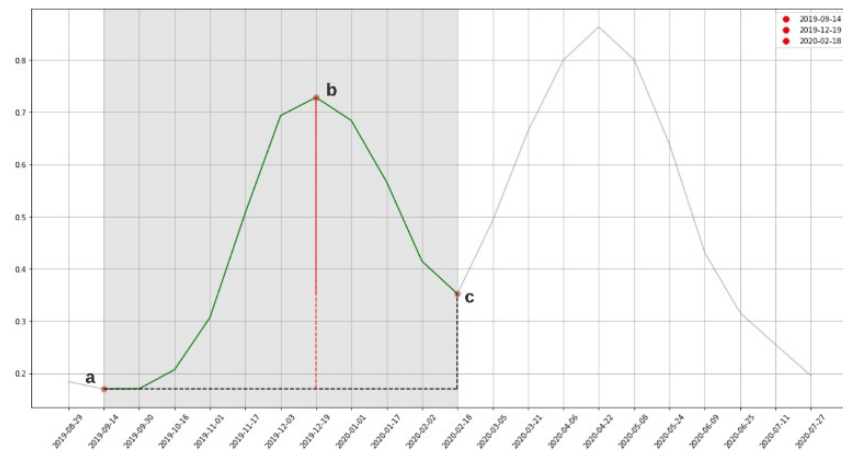
WTSS e WLTS – Interface gráfica – BDC Explorer e TerraCollect



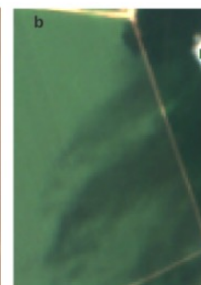
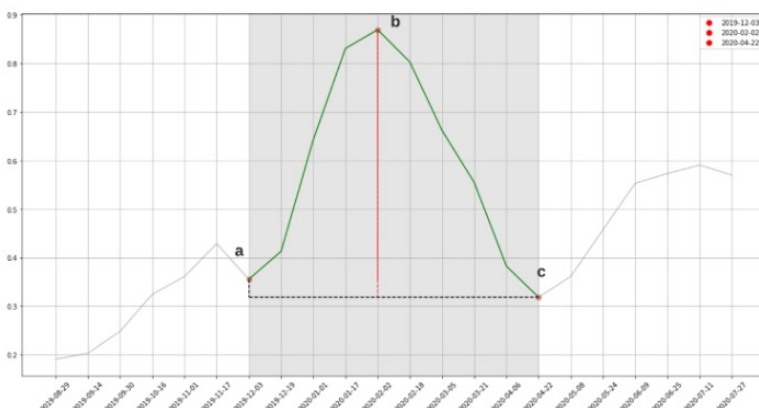
Web Crop Phenology Metrics Service (WCPMS)



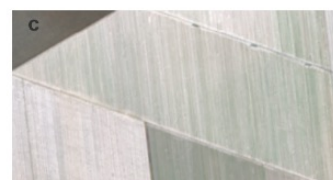
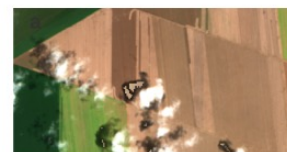
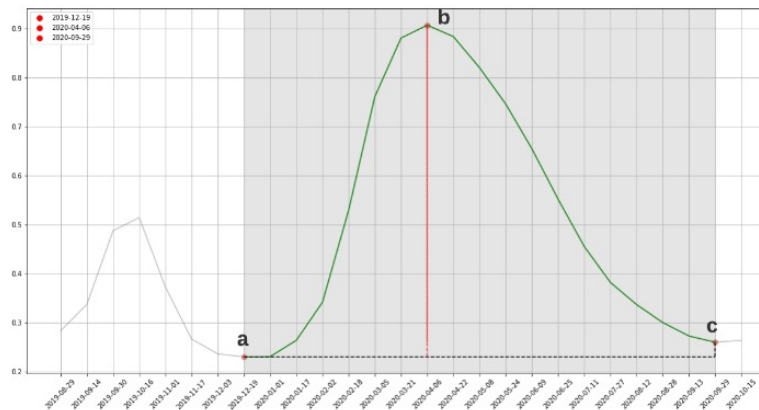
(a)



(b)

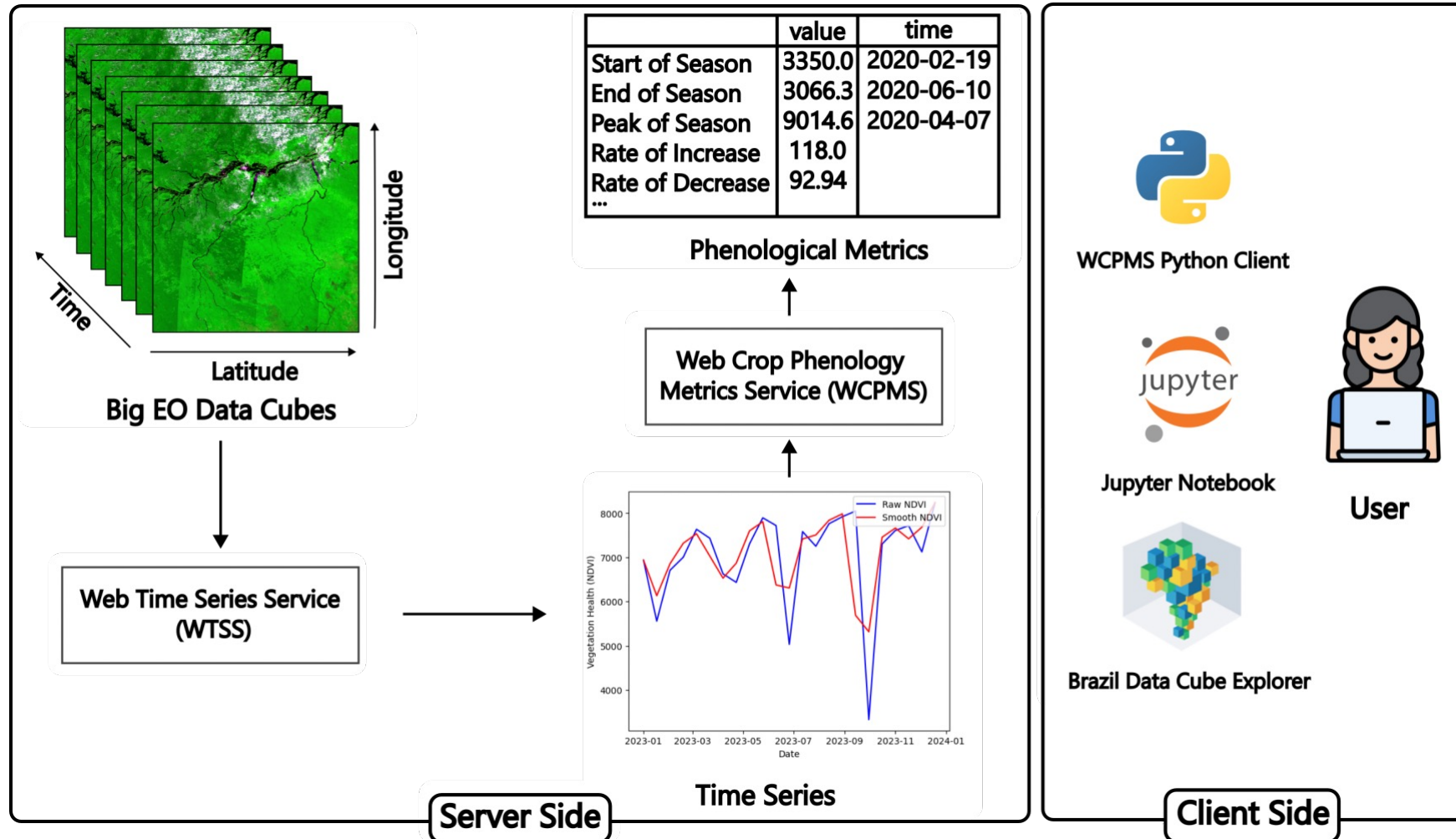


(c)



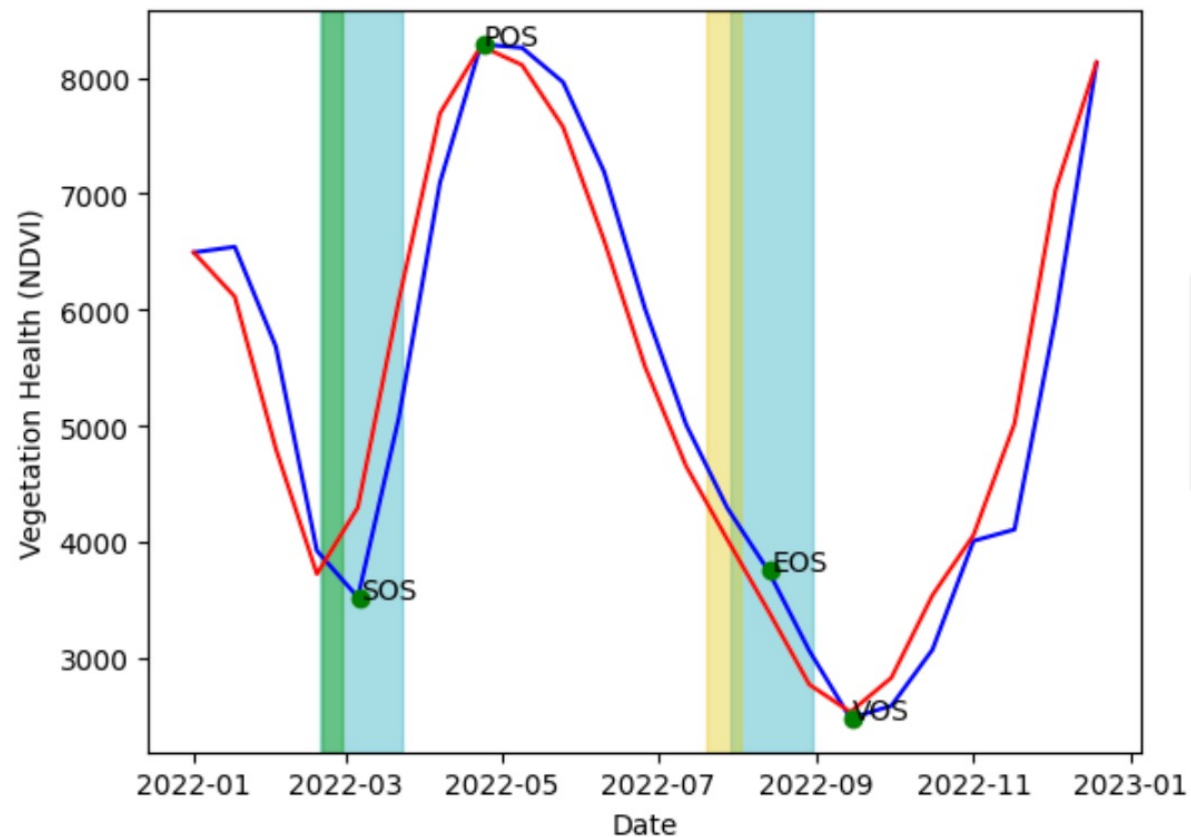
Métricas fenológicas de *início, fim e máximo* vigor vegetativo de plantio extraídas para soja (a), milho de primeira safra (b) e algodão (c) utilizando series temporais NDVI dos cubos Sentinel-2 (16 dias) do BDC.

Web Crop Phenology Metrics Service (WCPMS)

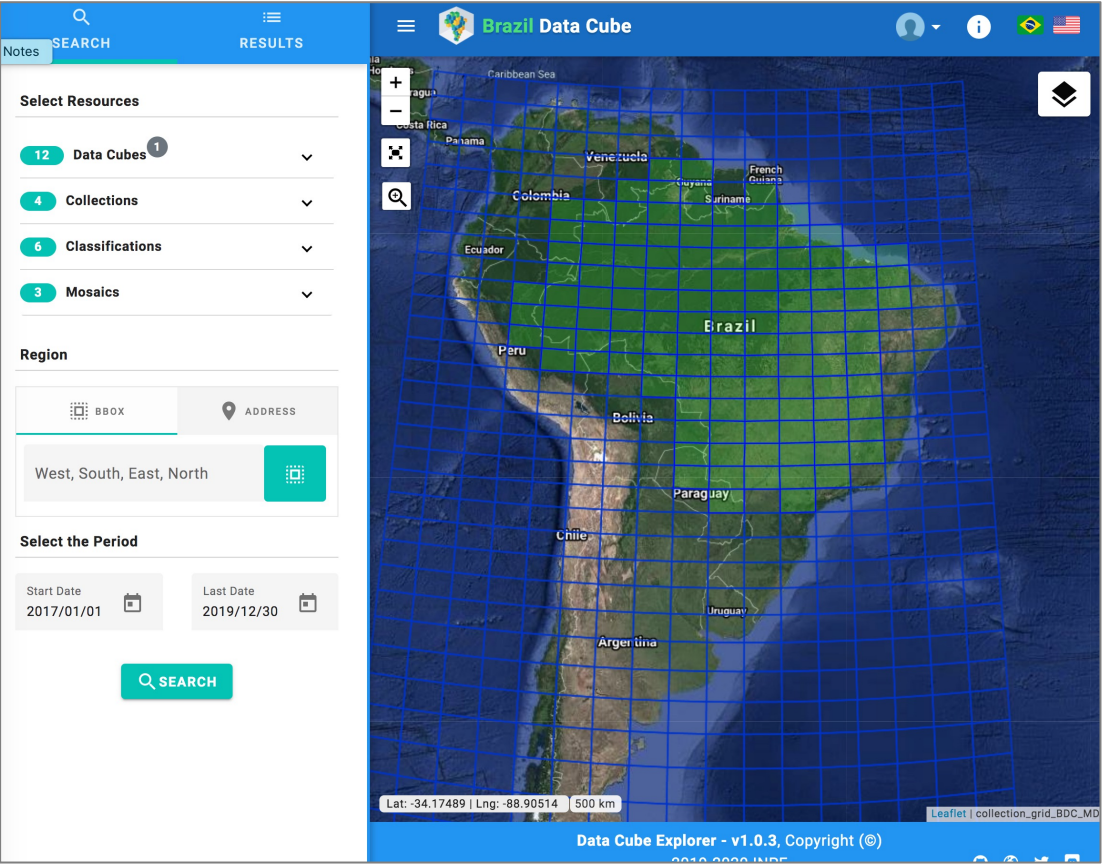


Web Crop Phenology Metrics Service (WCPMS)

```
plot_advanced_phenometrics(cube=datacube, ds_phenos=pms[9], shape=polygon, start_sowing="ope_inici  
o_plantio", end_sowing="ope_fim_plantio", start_harvesting="ope_inicio_colheita", end_harvesting  
="ope_fim_colheita")
```

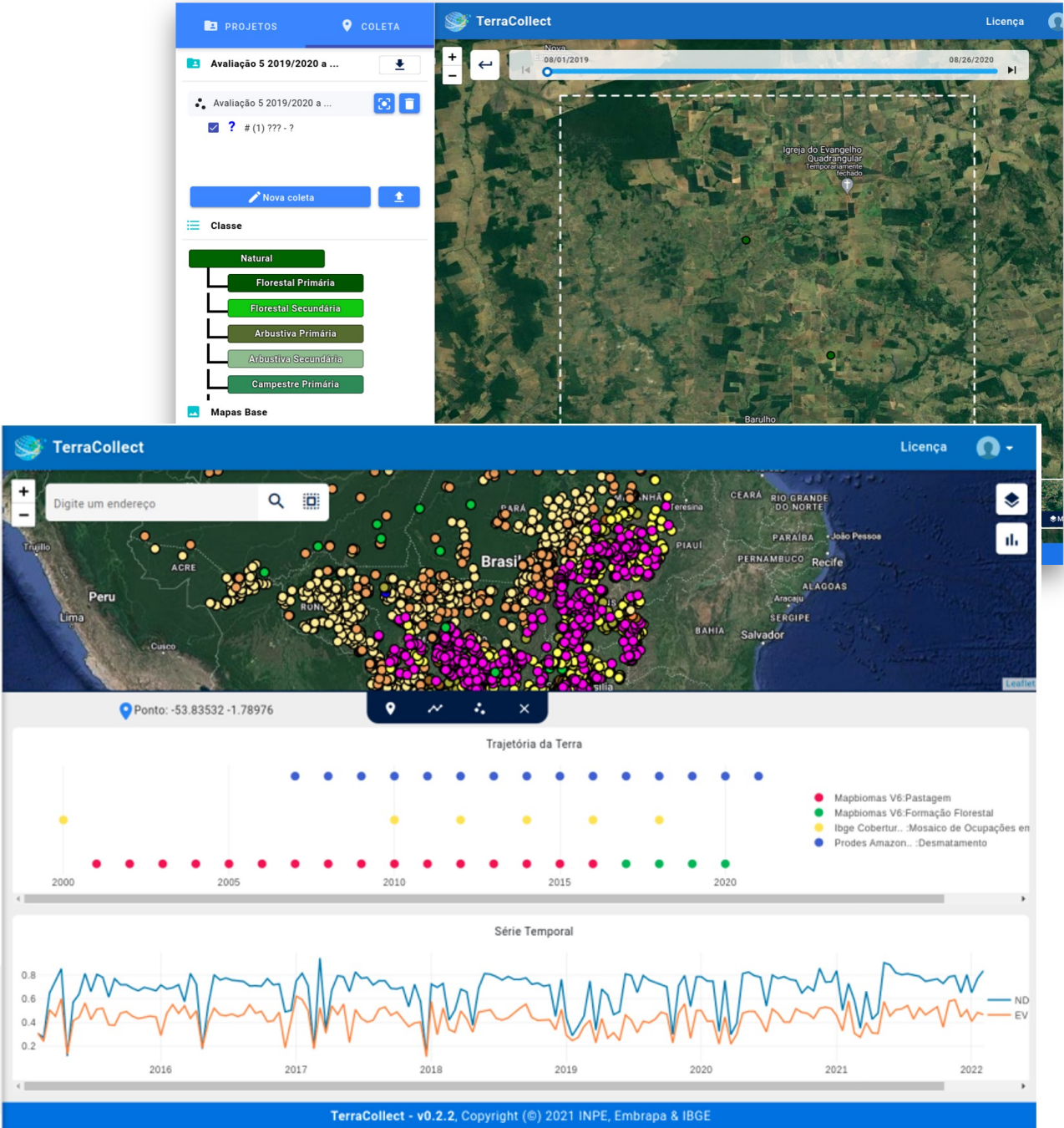


BDC Explorer

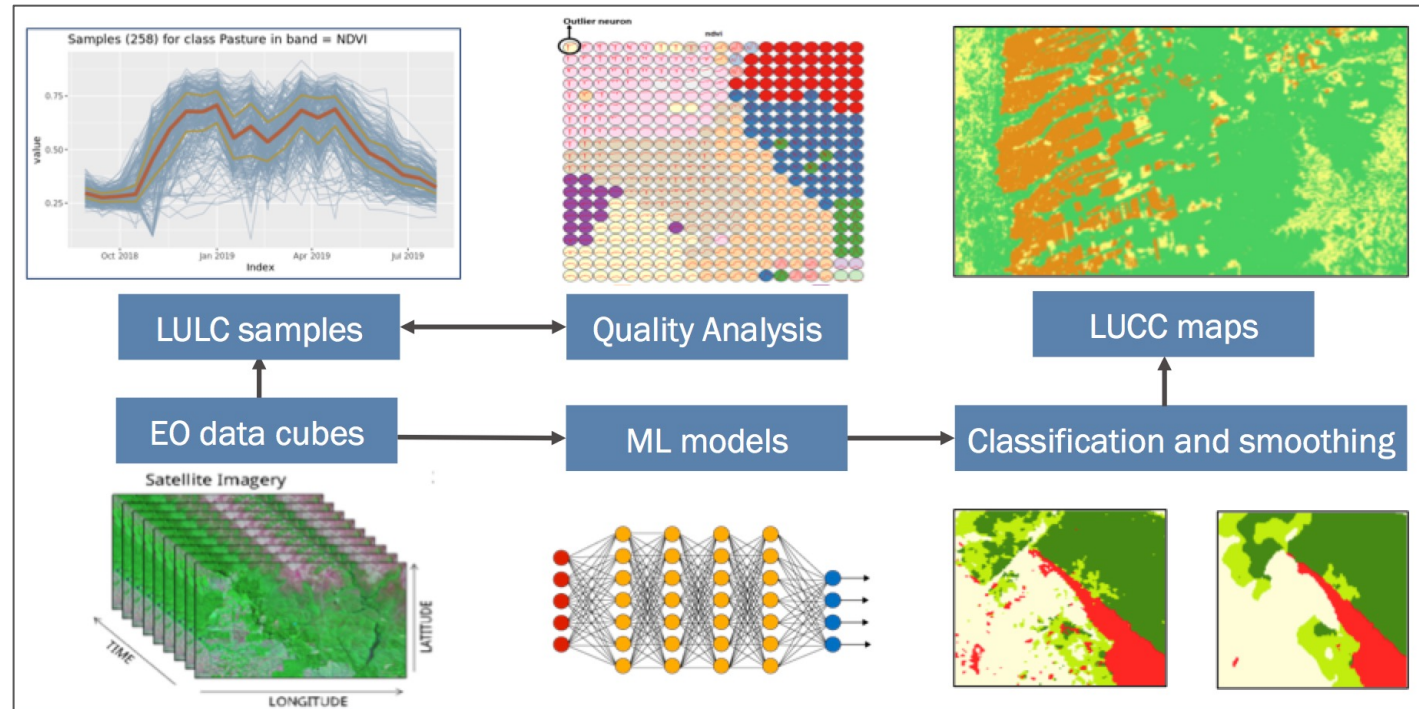


<https://data.inpe.br/bdc/explorer/explore>

TerraCollect



SITS (Satellite Image Time Series) R package



```
cube <- sits_cube(source = "BDC",  
                  collection = "S2_10_16D",  
                  name = "s2_cube",  
                  bands = c("NDVI", "EVI"),  
                  tiles = "022024", start_date = "2018-09-01", end_date = "2019-08-28")  
  
samples <- readRDS(url("https://bdc.dpi.inpe.br/rds/S2_10_16D.rds"))  
  
mlp_model <- sits_deeplearning(layers = c(512, 512, 512, 512, 512), activation = "relu")  
  
dl_model <- sits_train(samples, mlp_model)  
  
result <- sits_classify(data = cube, ml_model = dl_model, output_dir = tempdir())
```

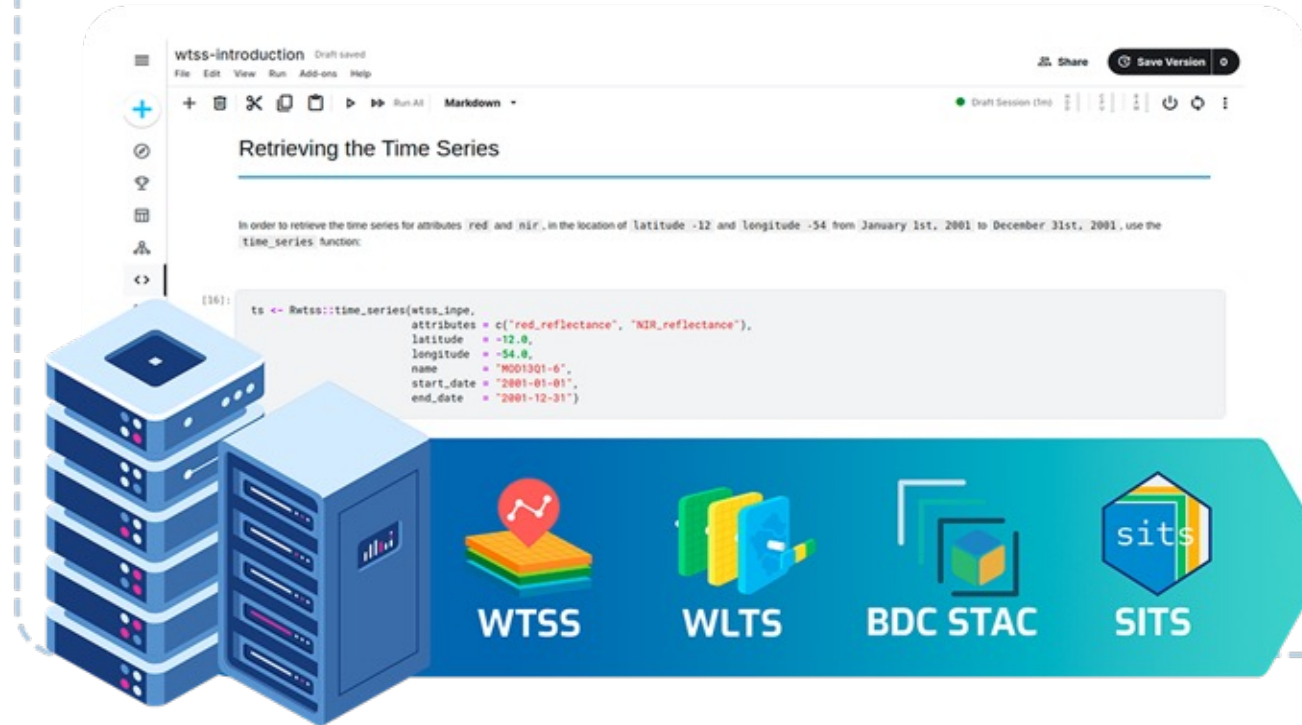
<https://github.com/e-sensing>

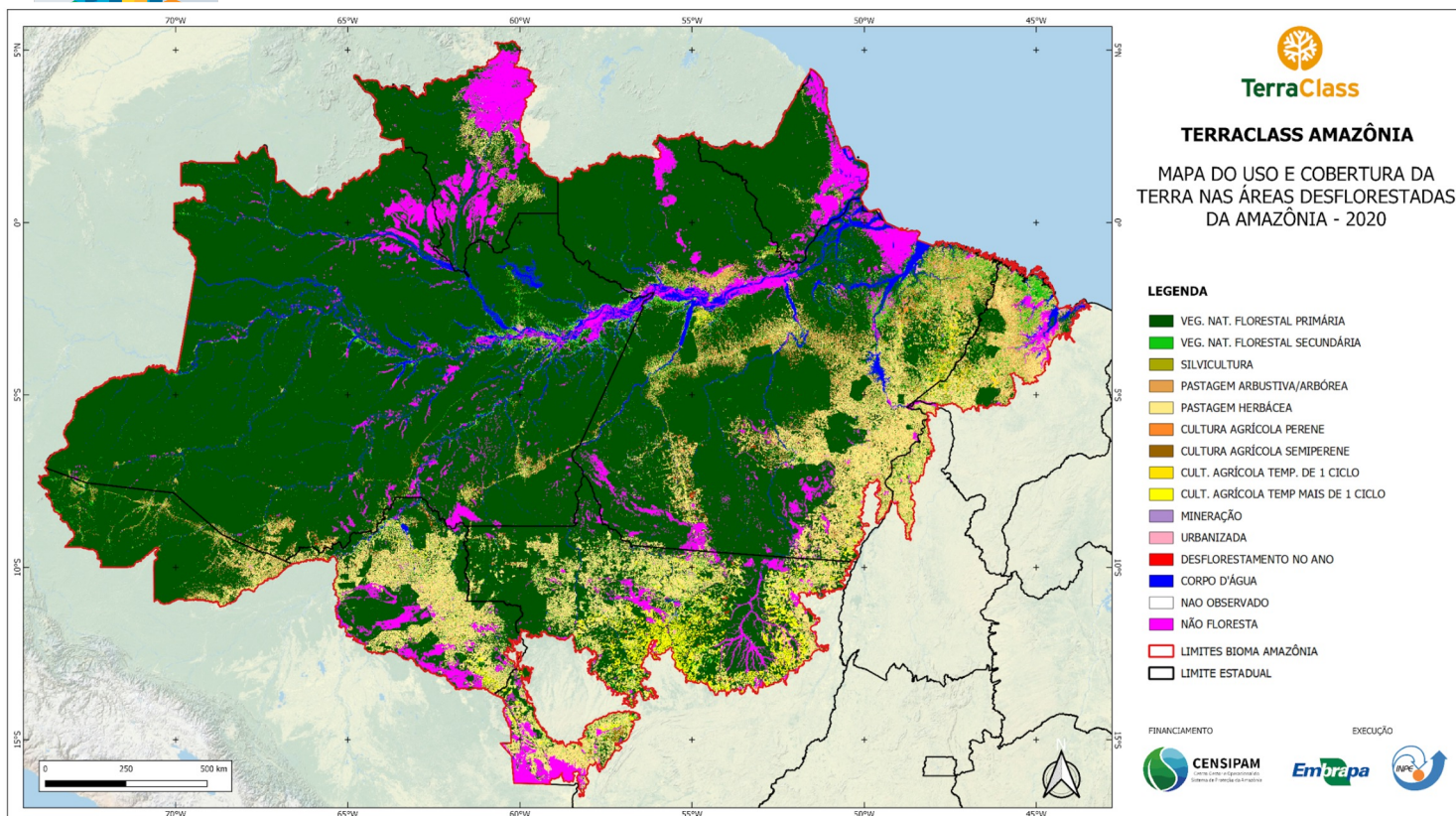


BDC-Lab: Geospatial Data Science Computational Environment

Server-side processing in the INPE's infrastructure, without needing to download images in personal computers.

BDCLab - Geospatial Data Science Computational Environment





33 Terabytes (292 tiles)
Sentinel-2 data cubes (16-days)
25,000 samples
Random Forest / tempCNN

Server-side processing in the INPE's infrastructure, without needing to download images in personal computers.



Embrapa



IBGE

INPE Data Center

Dell EMC HPC egeon



66 processadores e 200 Teraflops
BeeGFS (Alta performance) 500 TB
Dell ME484 (Alta densidade) 1 PB

Cray XE6 and CRAY XC50



880 processadores e ~413 Teraflops
XE6 Lustre (Alta performance) 860 TB
XE6 StorNext (Alta densidade) 2.65 PB
XC 50 Cray Sonextion (Alta performance) 986 TB

Courtesy: Ivan Márcio Barbosa

INPE Data Center

255 Servers, Data Storage with tiers (SSD, SAS and tape library) 12PB online and 4PB tape LTO



Courtesy: Ivan Márcio Barbosa



Ambiente de Computação Interativa: JupyterHub

JupyterLab interface showing a file browser on the left with a list of notebooks. The main area displays the '00_TableOfContents.ipynb' notebook, which contains a title 'Land use and land cover classification in the Brazilian Cerrado biome using Brazil Data Cube', authors, an abstract, and a table of contents.

Table of Contents

The Jupyter Notebooks are organized as follows:

- Extracting time series from sample locations
- Land Use and Cover Mapping from CBERS-4/AWFI Data Cubes

JupyterLab interface showing the '01_ExtractTimeSeries.ipynb' notebook. The main area displays the 'Time Series Extraction' section, which includes a code cell for extracting time series data and two line plots showing NDVI values over time for 'Pasture' and 'Natural' classes.

Time Series Extraction

CBERS-4/AWFI (16 days 'stack')

The `sits_cube` function can be used to define the working data cube and the interest spectral bands and vegetation indices:

```
[7]: cb4_cube <- sits_cube(  
      type      = "BDC",  
      url       = "http://datacube-006.dpi.inpe.br:8010/stac/",  
      collection = "CB4_64_16D_STK-1",  
      start_date = start_date,  
      end_date   = end_date,  
      bands      = c("BAND15", "BAND14", "BAND13", "BAND16", "NDVI", "EVI")  
    )
```

In the above cell we provide:

- `type`: Inform that the data is from the Brazil Data Cube.
- `url`: The SpatioTemporal Data Cube API endpoint.
- `collection`: Define the collection name.
- `start_date` and `end_date`: Define the time range.

Classify the datacube

This is a time-consuming process

```
[9]: probs <- sits_classify(data = cube,  
                           ml_model = dl_model,  
                           memsize = classification_memsize,  
                           multicores = classification_multicores,  
                           roi = roi_classification_roi,  
                           output_dir = output_dir)
```

Using 2 blocks of size 888 x 2725
Starting classification at 2021-03-26 14:54:15
Elapsed time 19.5 minute(s).
Estimated total process time 39 minute(s)...
Classification finished at 2021-03-26 15:33:30. Total elapsed time: 39.2minute(s).

Generate classification label map

```
[10]: probs_smoothed <- sits_smooth(probs, type = "bayes", output_dir = output_dir)  
      labels <- sits_label_classification(probs_smoothed, output_dir = output_dir)
```

Visualizing classification map



Ambiente de Computação Interativa: RStudio

The screenshot shows the RStudio Server interface. The top bar includes the R logo and menu items: File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help. Below the menu is a toolbar with icons for file operations and a 'Go to file/function' search bar. The main editor displays a notebook with R code. The code includes comments and function calls for downloading data from the Brazil Data Cube (BDC) and defining parameters for a classification task. The code is organized into sections: **Parameters** and **Samples and ROI definition**. The console at the bottom shows the execution of the code, with the current directory set to /data/Examples/bdc-article/.

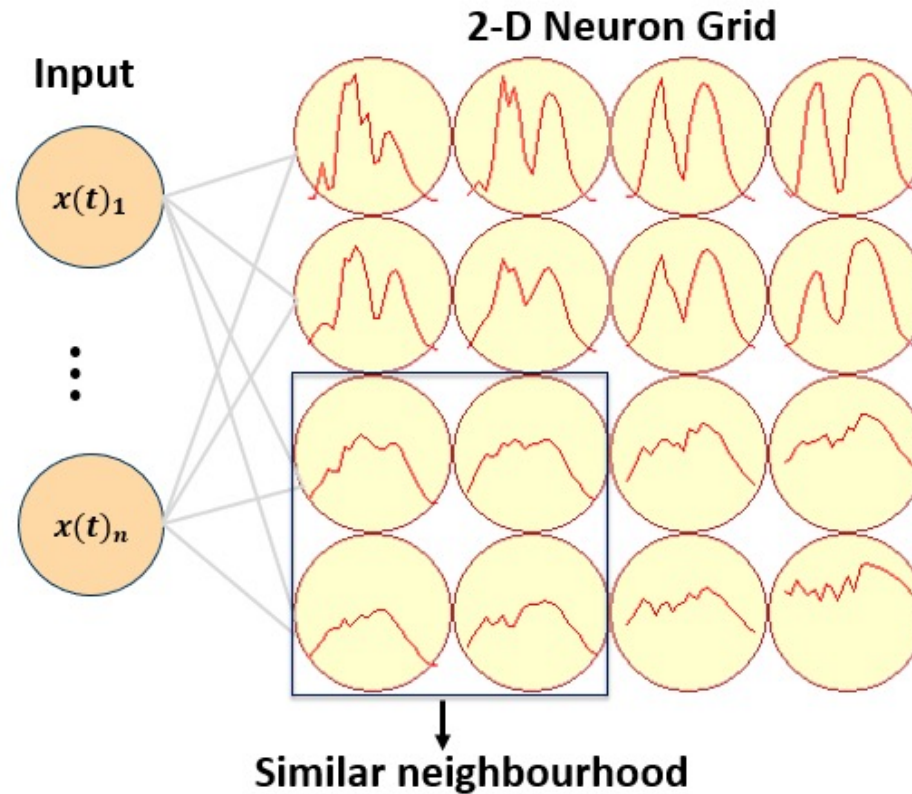
```
66 **Parameters**
67
68 If you want to download and run this notebook in a workflow as a script, you can perform its
69 parameterization through the [papermill library](https://github.com/interact/papermill). The access to
70 the Brazil Data Cube (BDC) data products requires an access key. To request your access key, please,
71 contact the BDC team at brazildatacube@inpe.br. Define the 'BDC_ACCESS_KEY' env variable to access to
72 use the BDC Services.
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```

The screenshot shows a web browser displaying the 'Time Series Extraction' page on the brazildatacube.dpi.inpe.br website. The page includes a section titled 'CBERS-4/AWFI (16 days 'stack')' and a description of the `sits_cube` function. Below the text, there is a code editor showing R code for defining the `sits_cube` function and retrieving time series data. The code includes comments and function calls for downloading data from the Brazil Data Cube (BDC) and defining parameters for a classification task. The code is organized into sections: **Parameters** and **Samples and ROI definition**. The console at the bottom shows the execution of the code, with the current directory set to /data/Examples/bdc-article/.

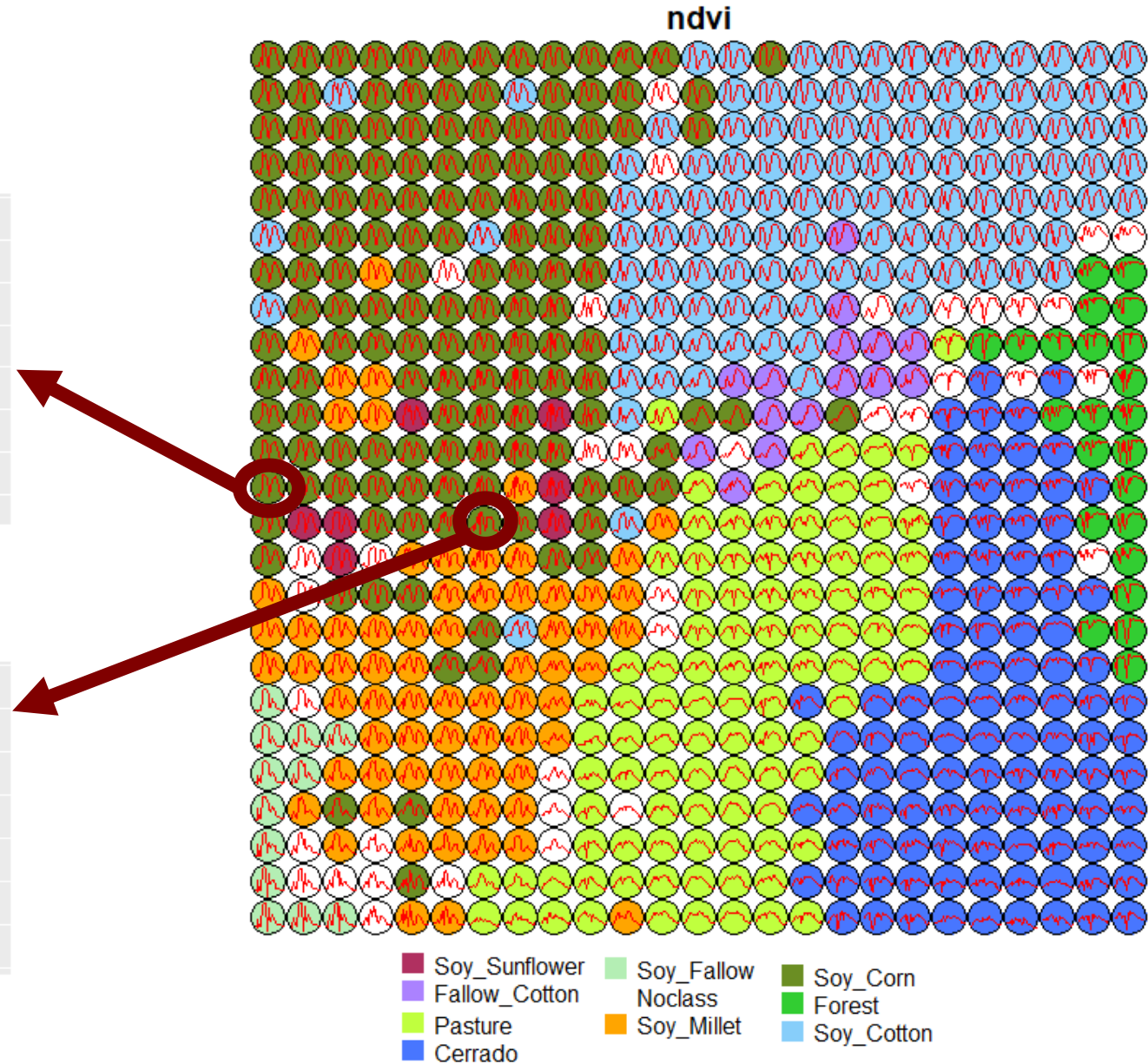
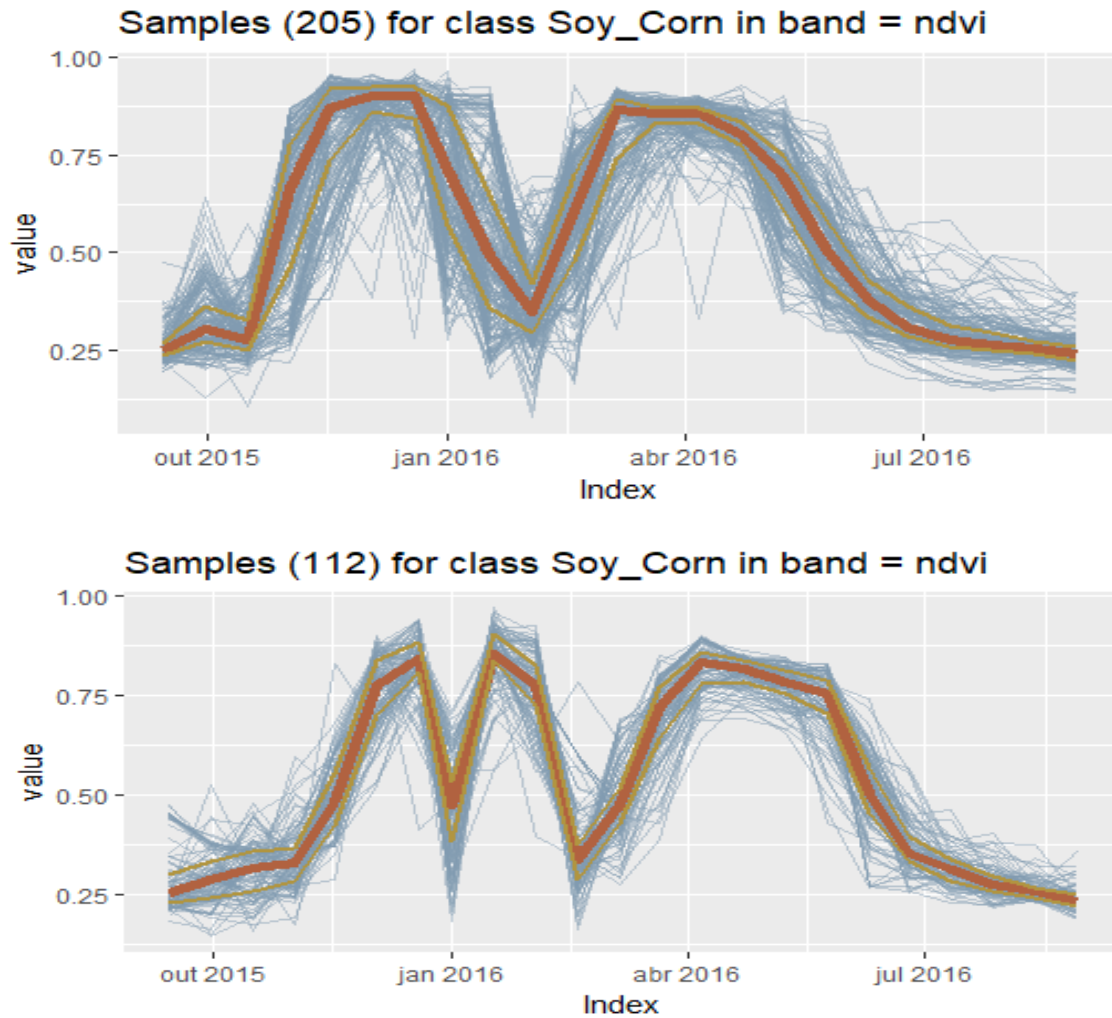
```
cb4_cube <- sits_cube(
  type = "BDC",
  url = "http://datacube-006.dpi.inpe.br",
  collection = "CB4_64_160_STK-1",
  start_date = start_date,
  end_date = end_date,
  bands = c("BAND15", "BAND14", "BAND13")
)
```

Clustering of SITS

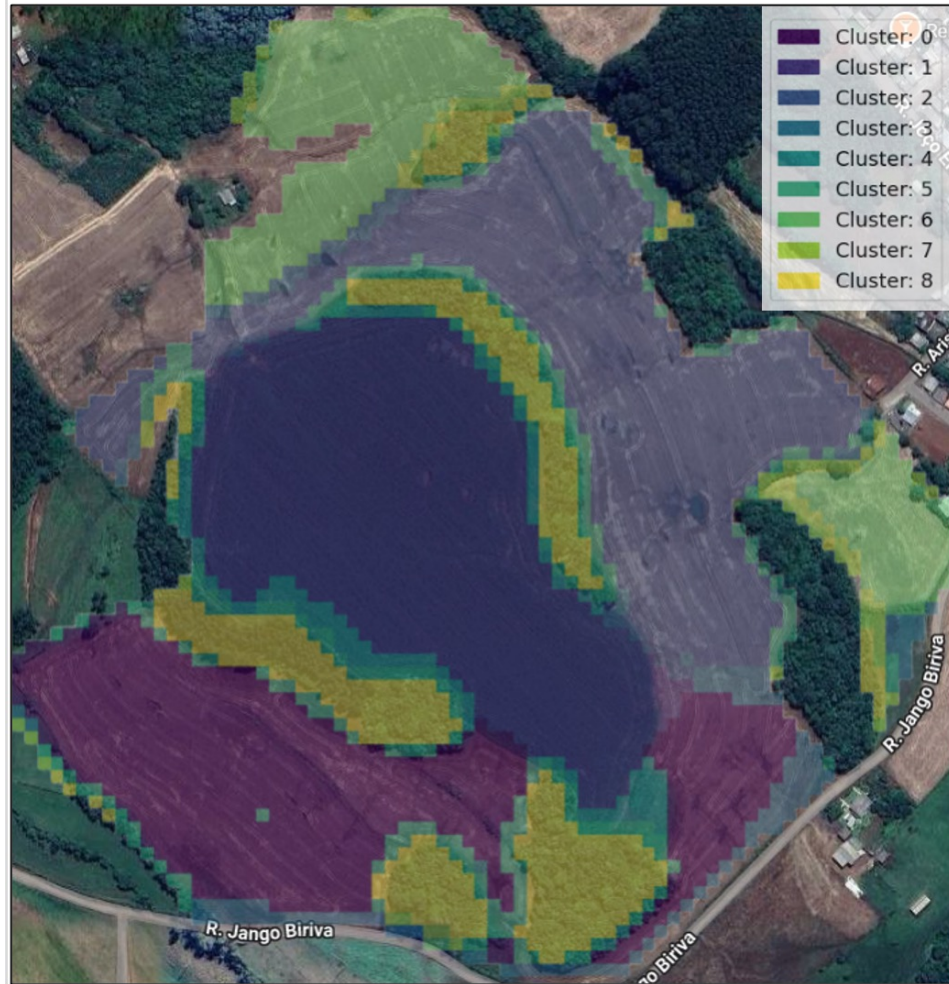
Self-Organizing Maps (SOM) neural network for SITS clustering



SOM to identify different SITS patterns

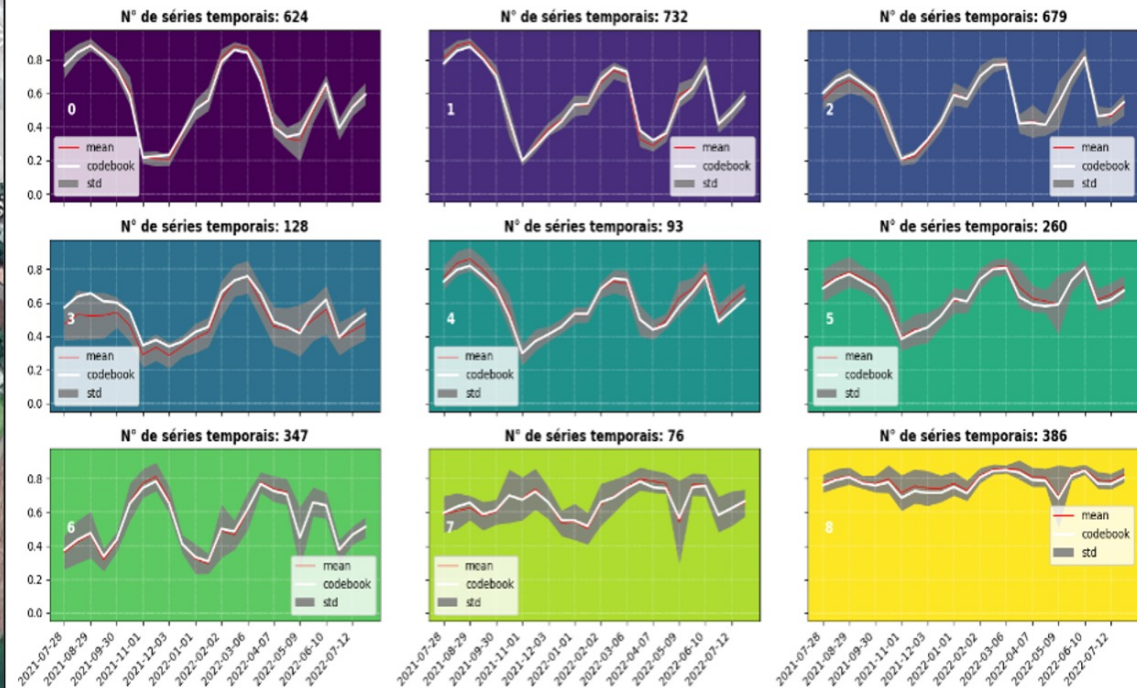


SITS patterns – dentro de uma gleba – Crédito Rural - SICOR



(A)

Vetores de Peso (NDVI) dos Neurônios SOM



(B)

SITS patterns – dentro de uma gleba – Crédito Rural - SICOR

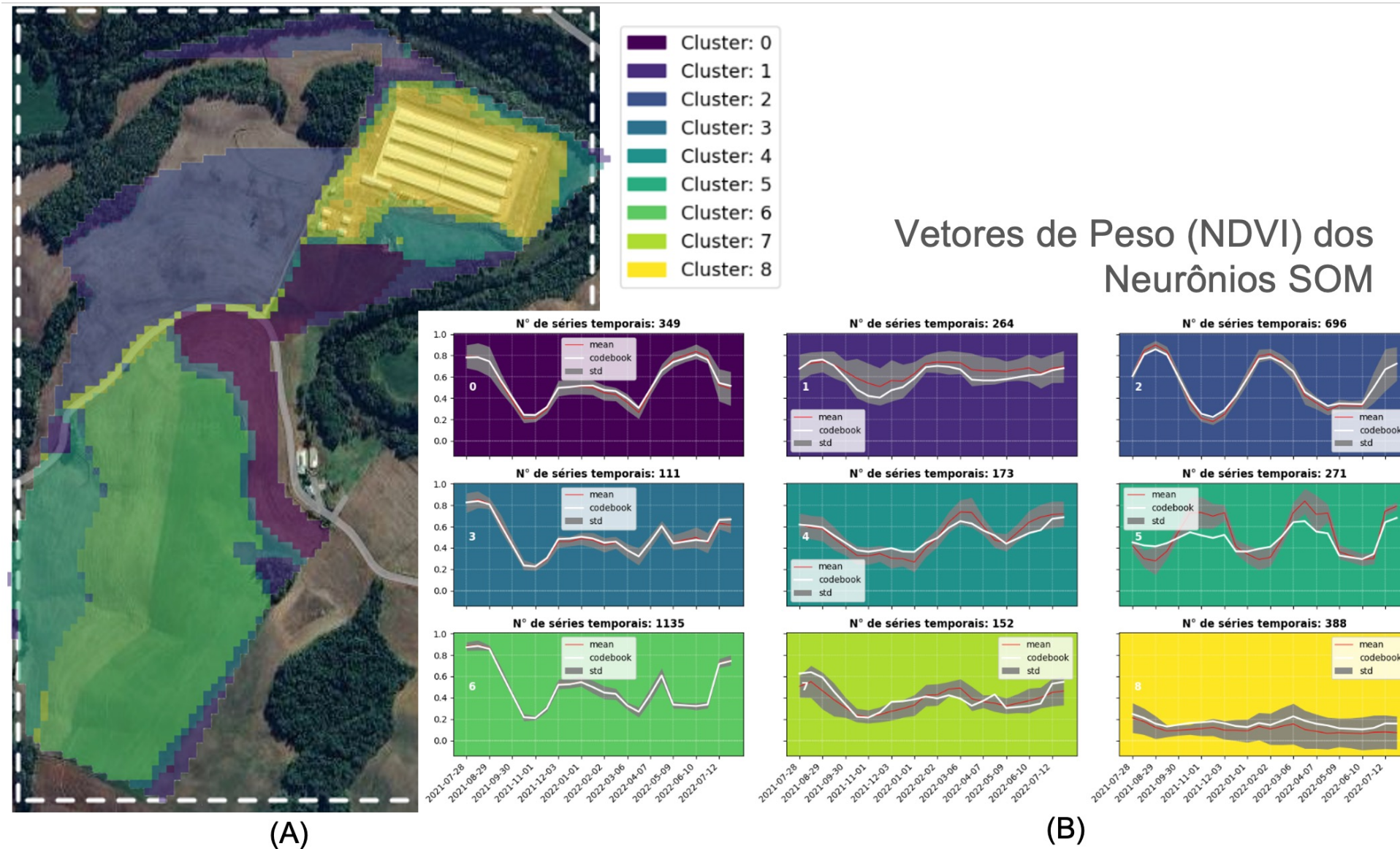


(A)



(B)

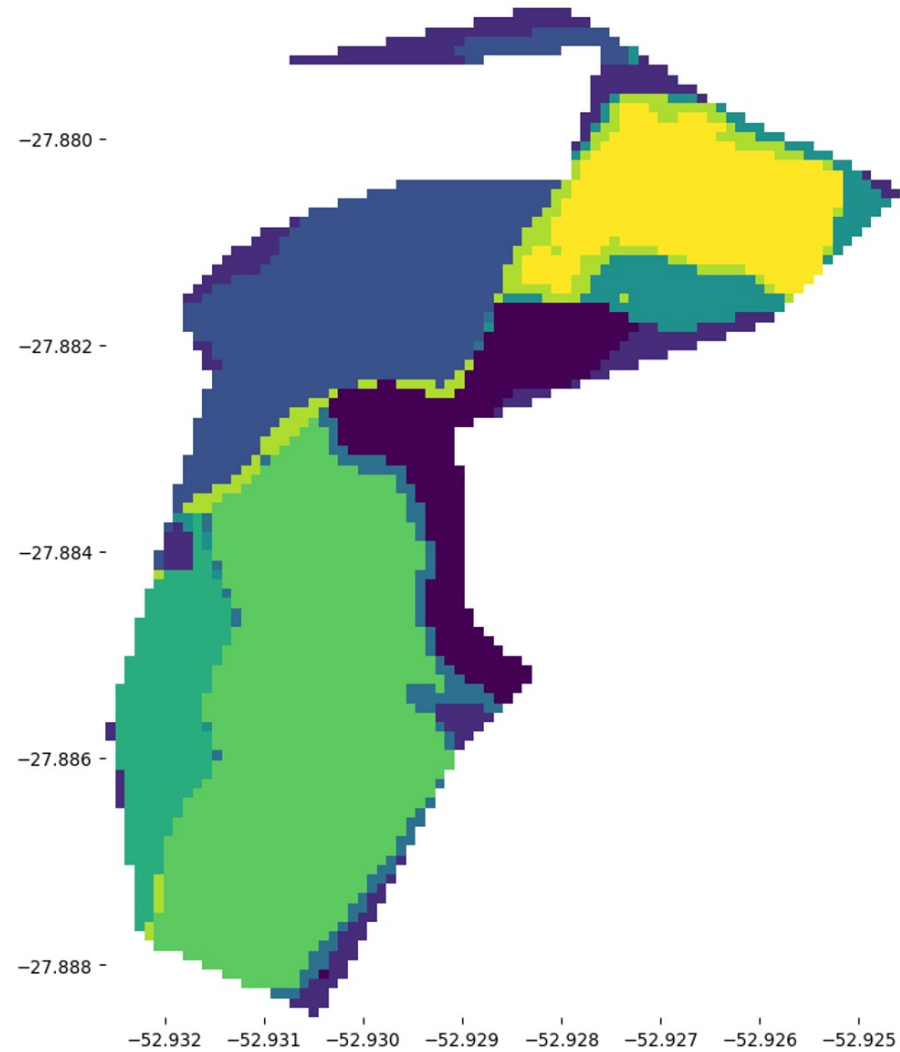
SITS patterns – dentro de uma gleba – Crédito Rural - SICOR



SITS patterns – dentro de uma gleba – Crédito Rural - SICOR



(A)



(B)



BRAZIL DATA CUBE
brazildatacube.org



brazildatacube.org



brazildatacube.dpi.inpe.br/portal/explore

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OBRIGADA!



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INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

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