SBSR

XXI SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO

Earth Observation Data Cubes and Time Series Analysis of Images

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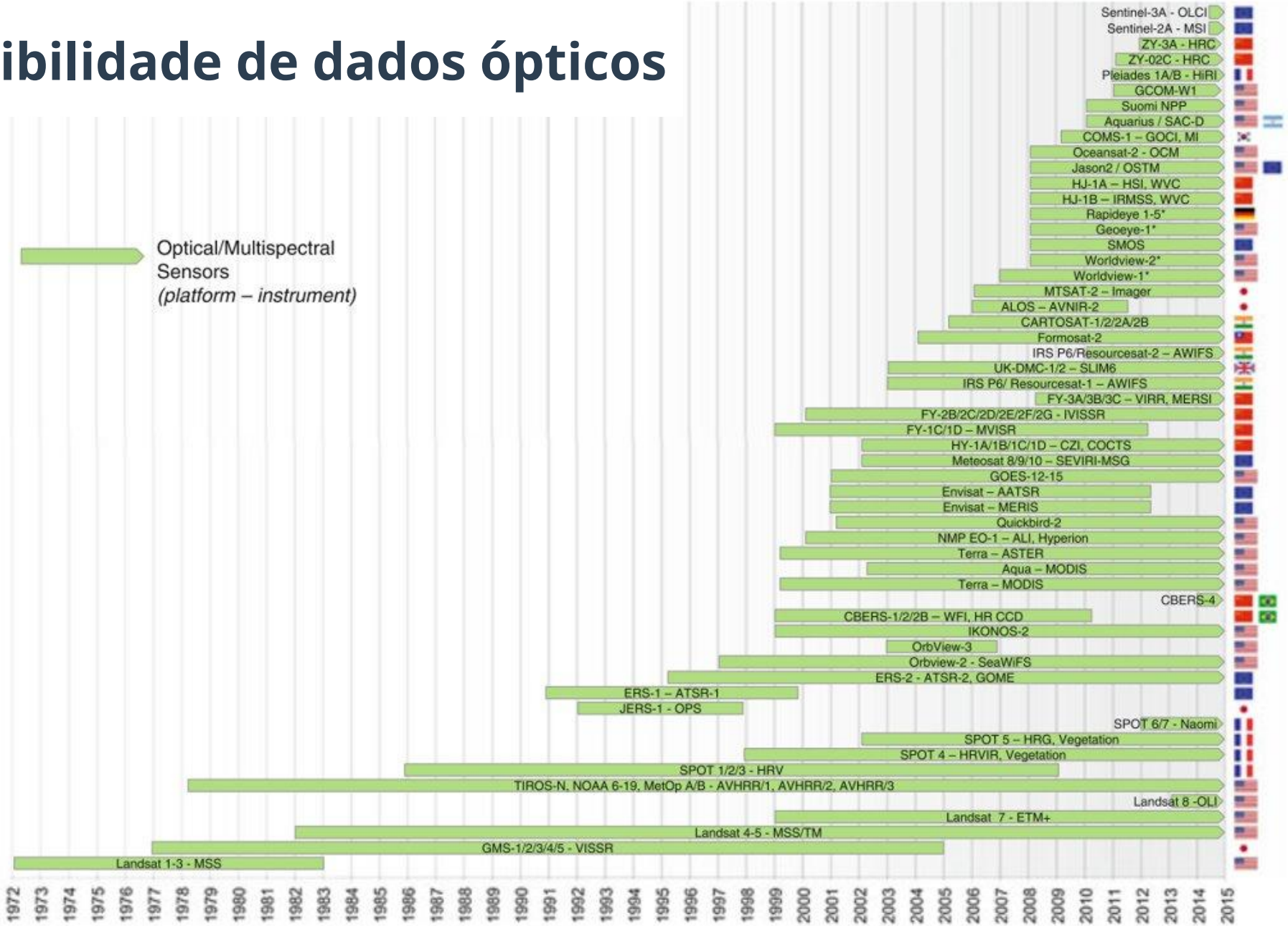
Instructors: Dr. Rennan de Freitas Bezerra Marujo, MSc. Felipe Carvalho de Souza, MSc. Abner Ernâni dos Anjos, MSc. Baggio Luiz de Castro e Silva, MSc. Felipe Menino Carlos e MSc. Gabriel Sansigolo.

INPE

Finep

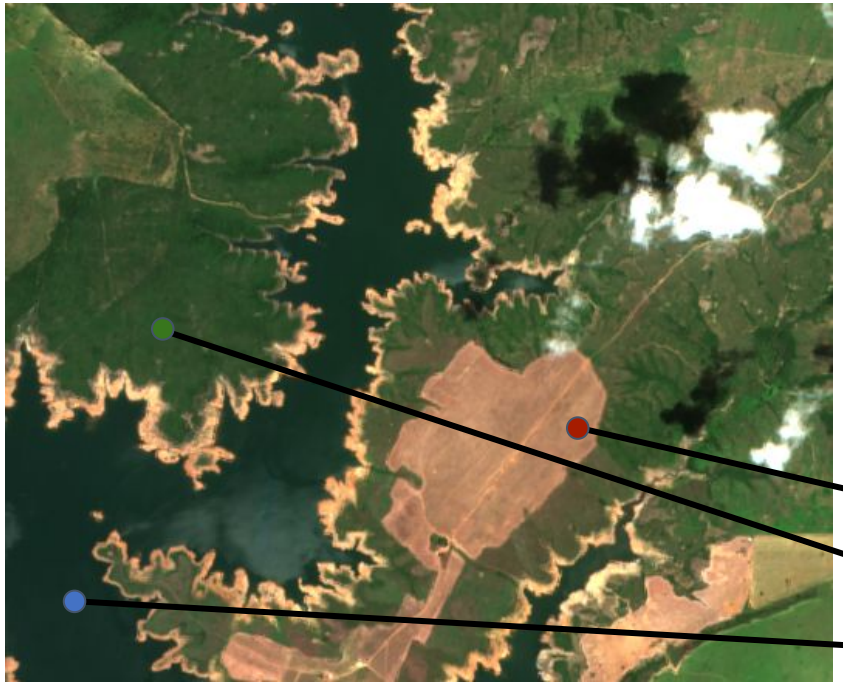
INOVAÇÃO E PESQUISA

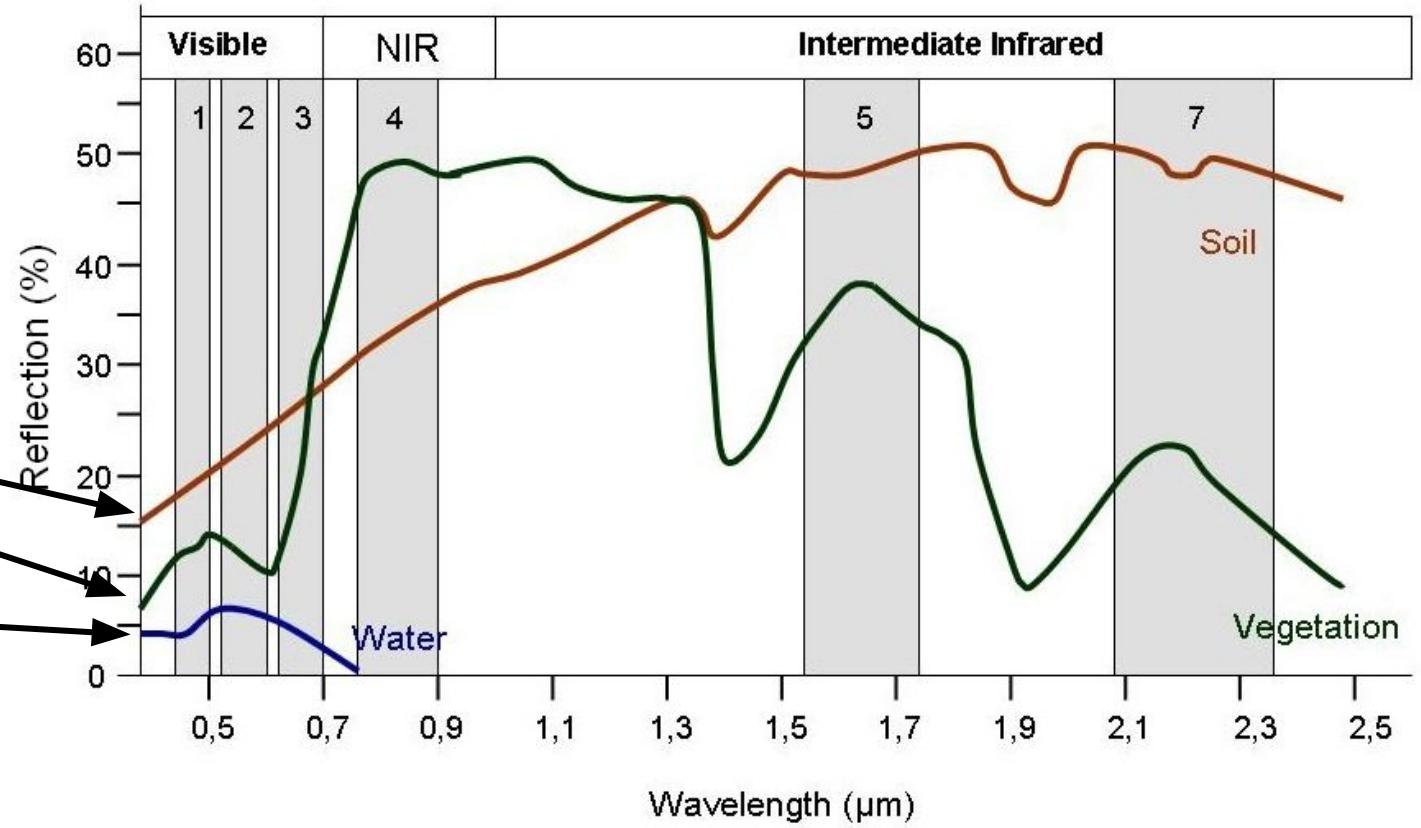
Disponibilidade de dados ópticos



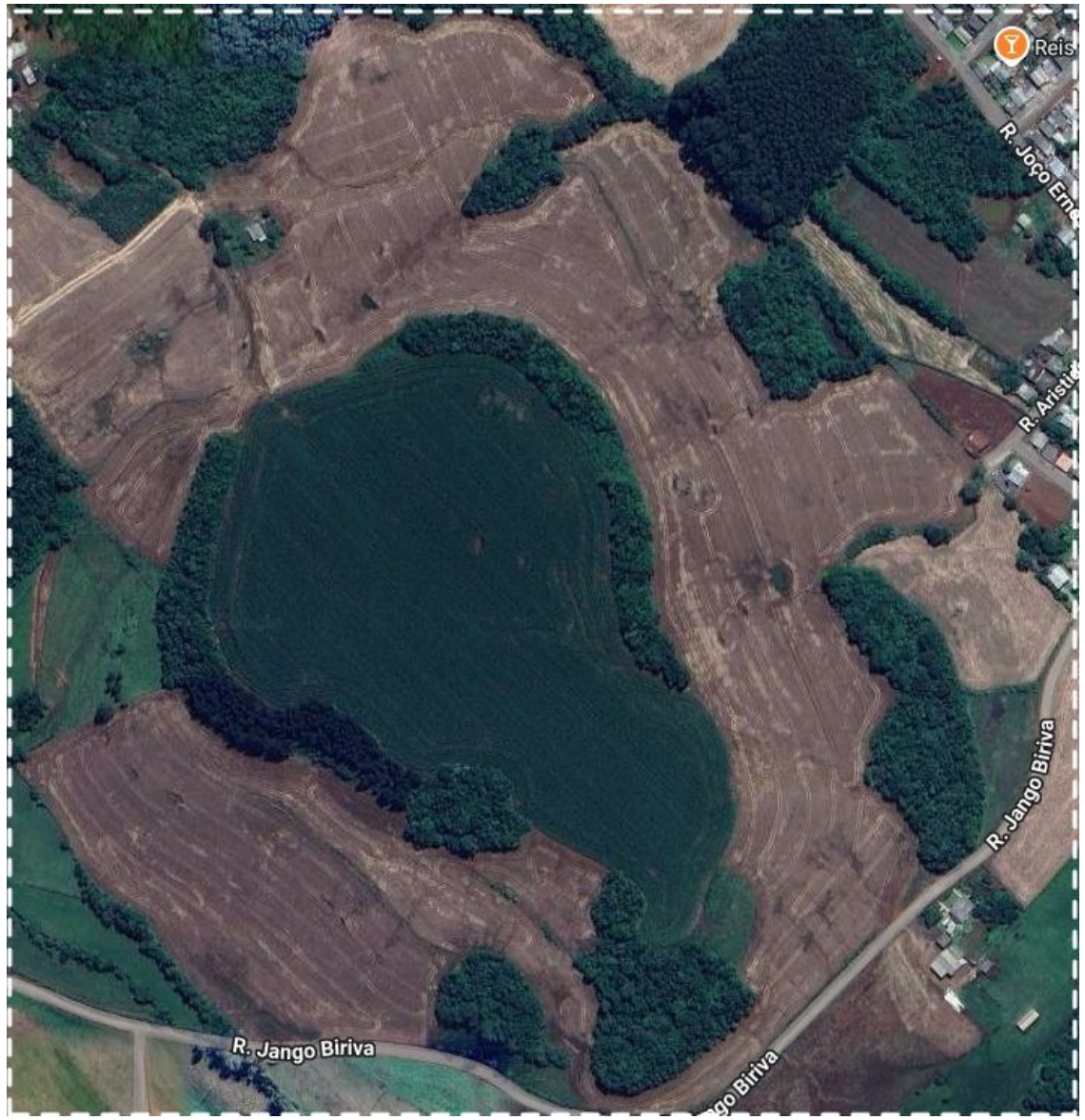
Source: Kuenzer et. al (2015)

Abordagem pixel a pixel

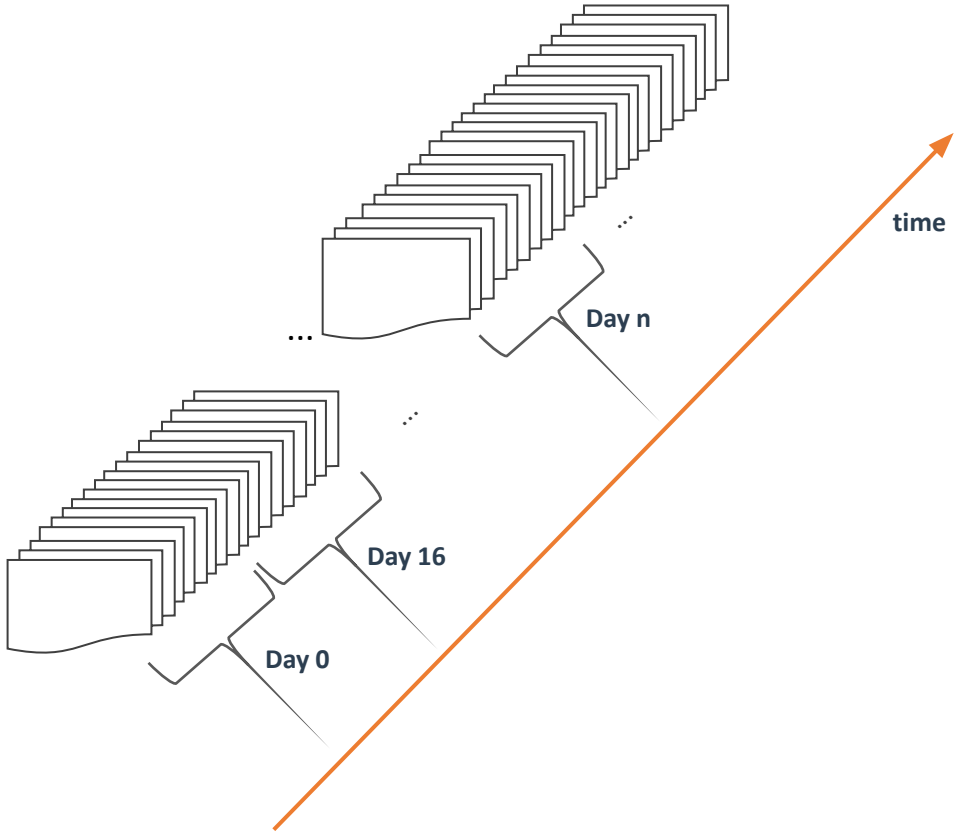


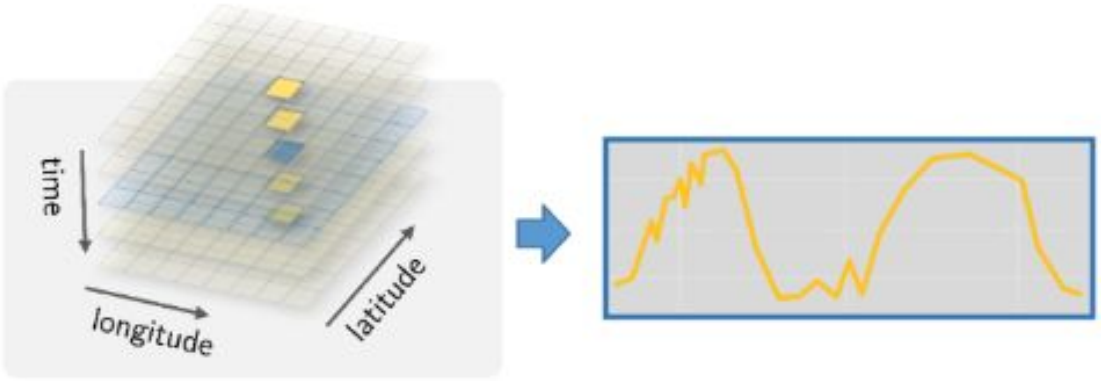


Abordagem por regiões

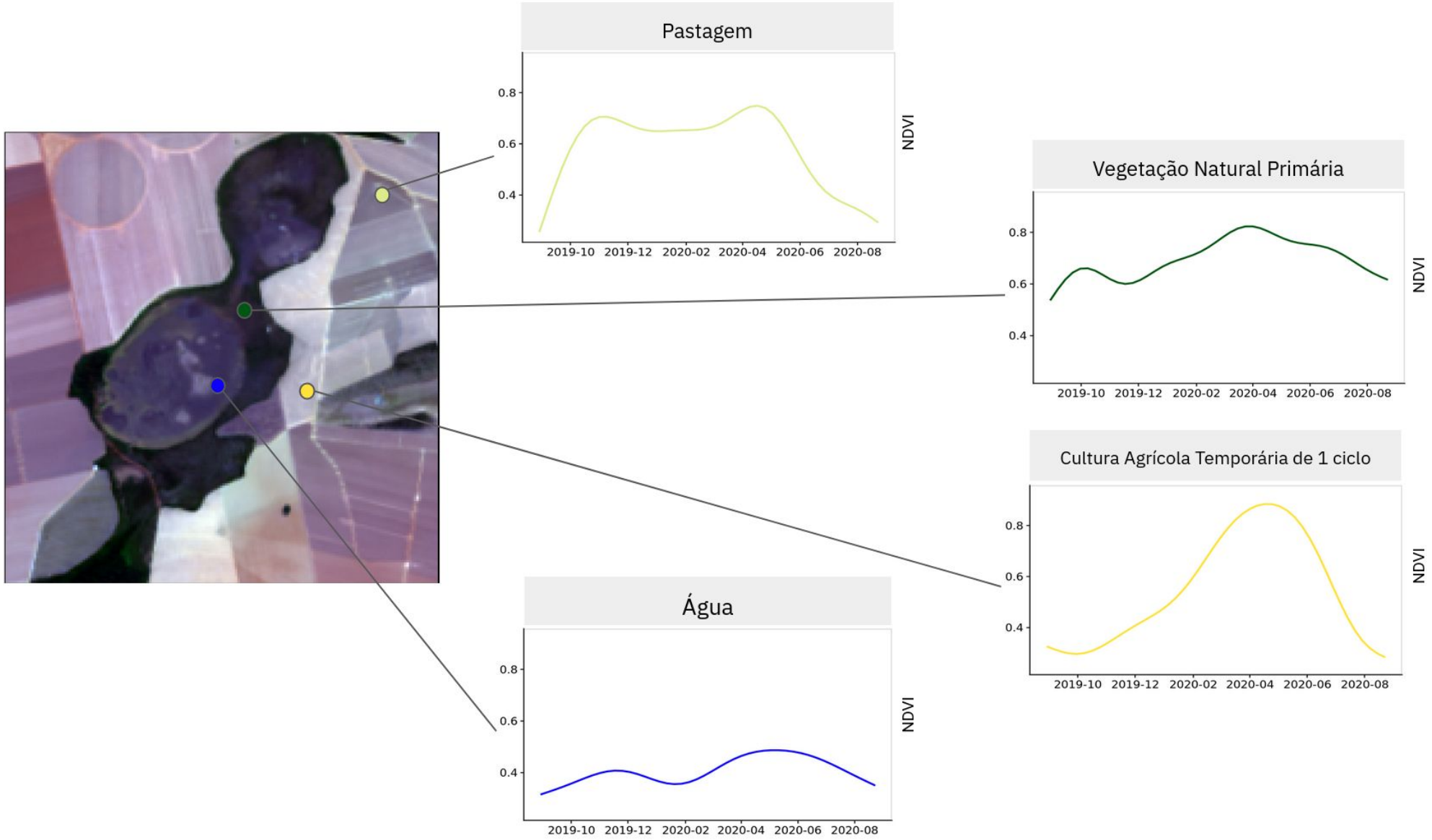


Abordagem por tempo: Time Series

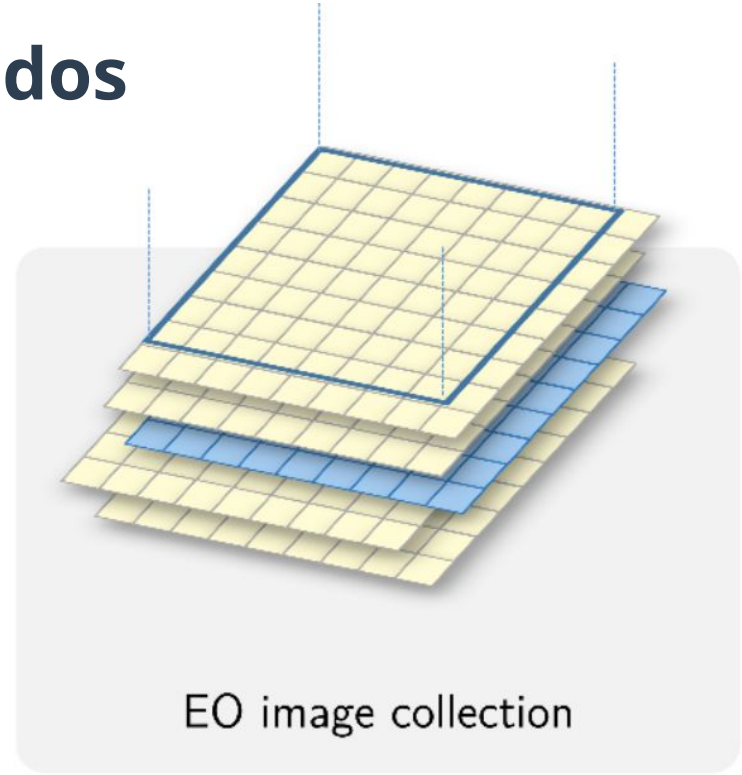




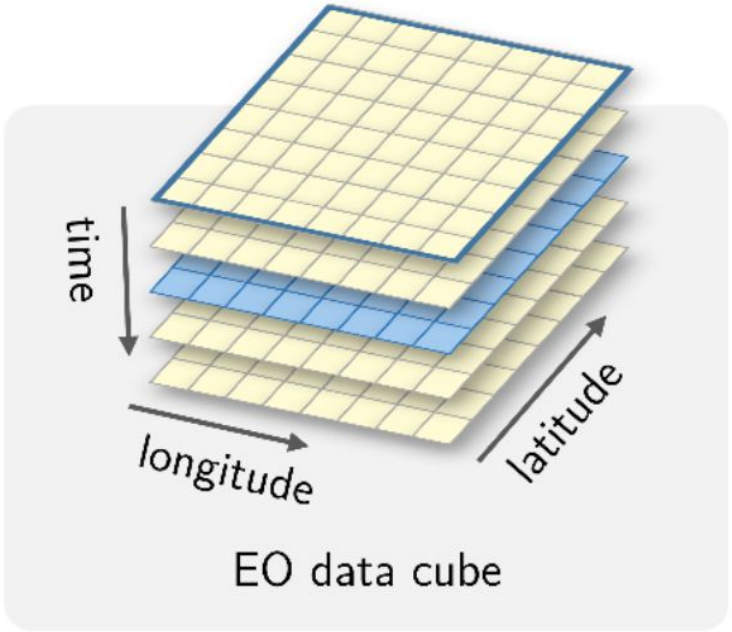
Caracterização de Séries Temporais



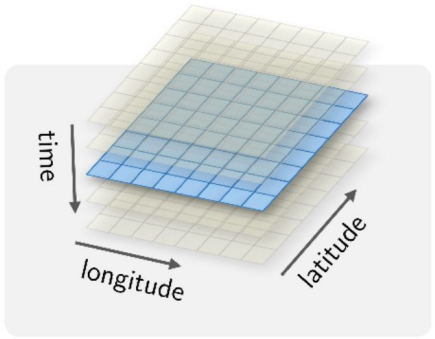
Cubos de Dados



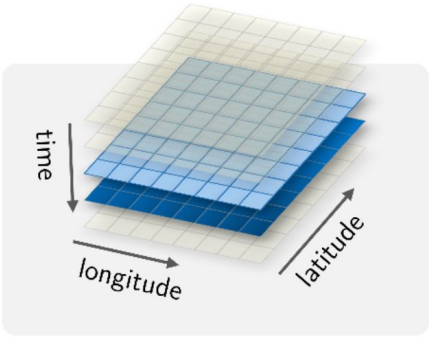
EO image collection



EO data cube

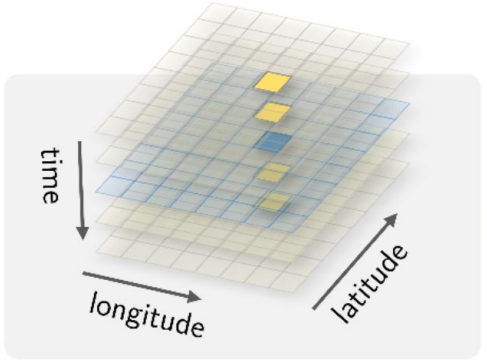


1 Time



2 Times

Image selection



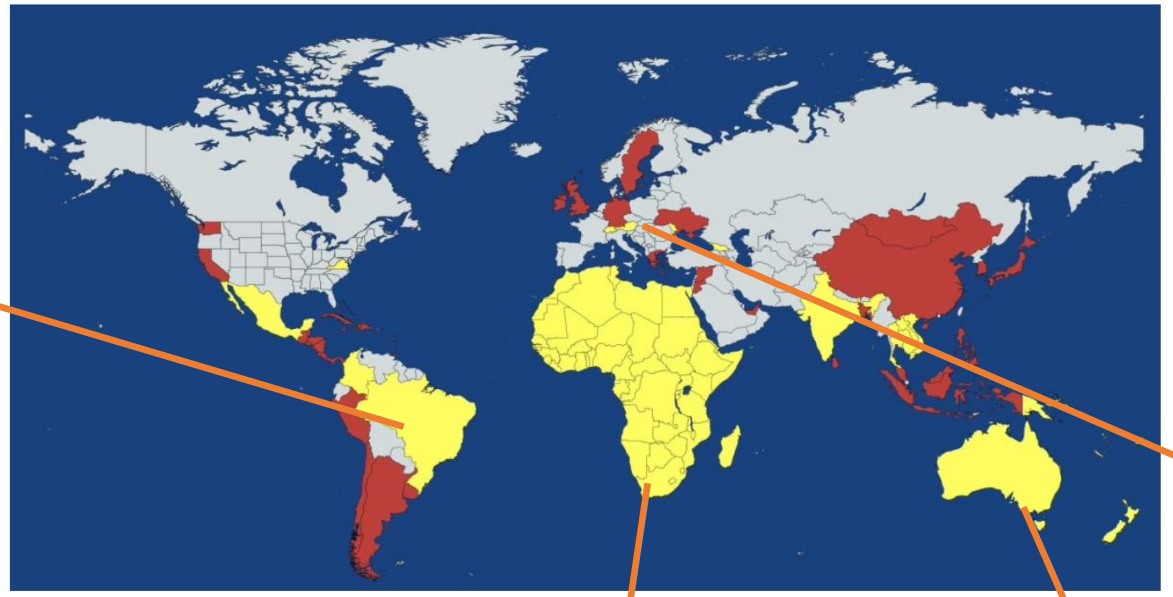
Time series extraction

Cubos de dados pelo mundo

Iniciativas similares

Source: [Sudmanns et al, 2022]

Amarelo: operational
Vermelho: em desenvolvimento



BRAZIL DATA CUBE

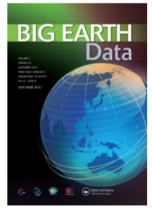
http://brazildatacube.org

data MDPI

Article

Paving the Way towards an Armenian Data Cube

https://www.swissdatacube.org/



Big Earth Data

Building an Earth Observations Data Cube: lessons learned from the Swiss Data Cube (SDC) on generating Analysis Ready Data (ARD)

ISSN: 2096-4471 (Print) 2574-5417 (Online) Journal homepage: http://www.tandfonline.com/loi/tbed20

Naciones Unidas CEPAL NASA INEGI

Digital Earth Americas

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

Digital Earth AFRICA

https://digitalearthafrica.org/

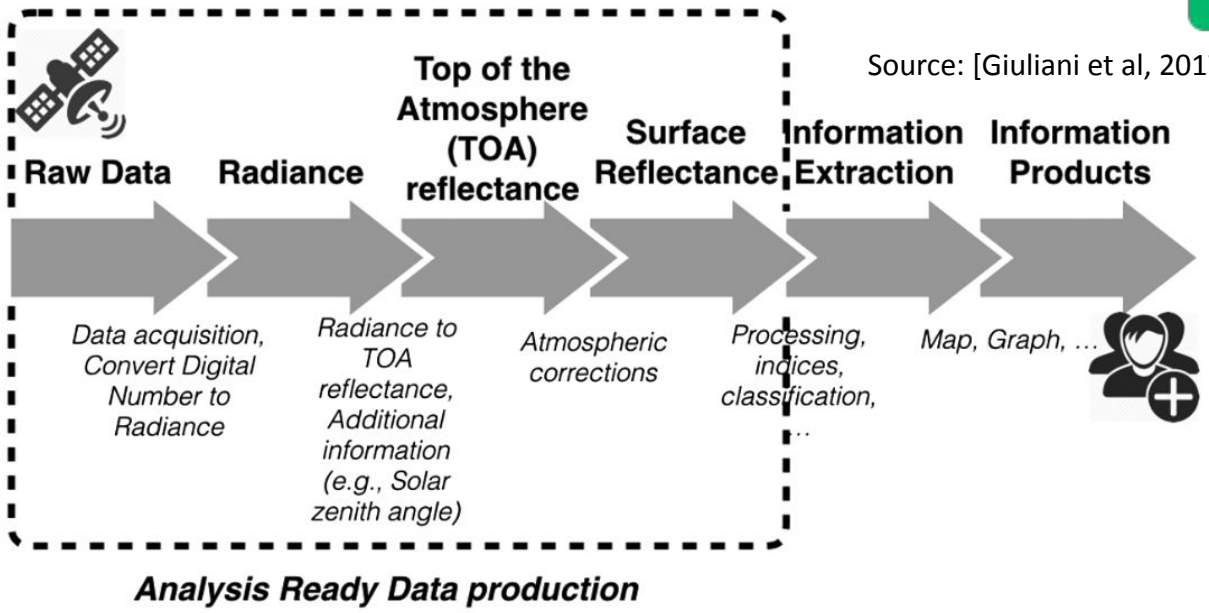
Digital Earth AUSTRALIA

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

Produção de ARD

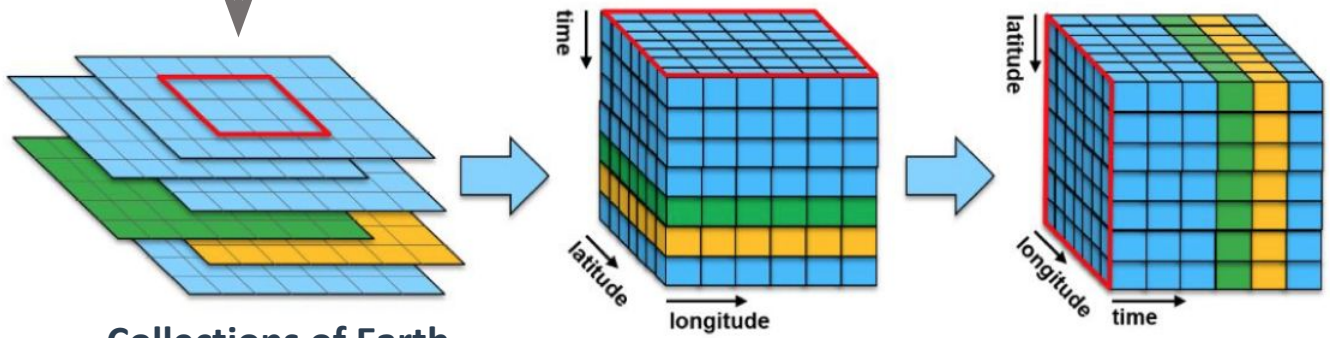
Analysis-Ready Data (ARD) de imagens de média resolução espacial para o Brasil: CBERS-4, CBERS-4A, AMAZONIA-1, Landsat 5-9, Sentinel 2, MODIS.

Source: [Giuliani et al, 2017]



Cubos de dados Multidimensionais

Source: [Kopp et al, 2019]



Collections of Earth observation satellite imagens – ARD

Data cubes – four-dimensional array.

Produção de ARD

USGS **Collection 2 L2** (Landsat-5 Landsat-7 Landsat-8 Landsat-9)

esa **Sentinel-1** (GRDH)
Sentinel-2 (L1C)
Sentinel-2 (L2A) → **L2A COG**
Sentinel-3 (OLCI)

NASA **MOD11A2**
MYD11A2
MOD13Q1
MYD13Q1

INPE **CBERS-4 DN** (MUX, WFI, PAN5, PAN10)
CBERS-4 SR (MUX, WFI)
CBERS-4A DN (WFI, WPM)
CBERS-4A SR (WFI)
AMAZONIA-1 SR (WFI)

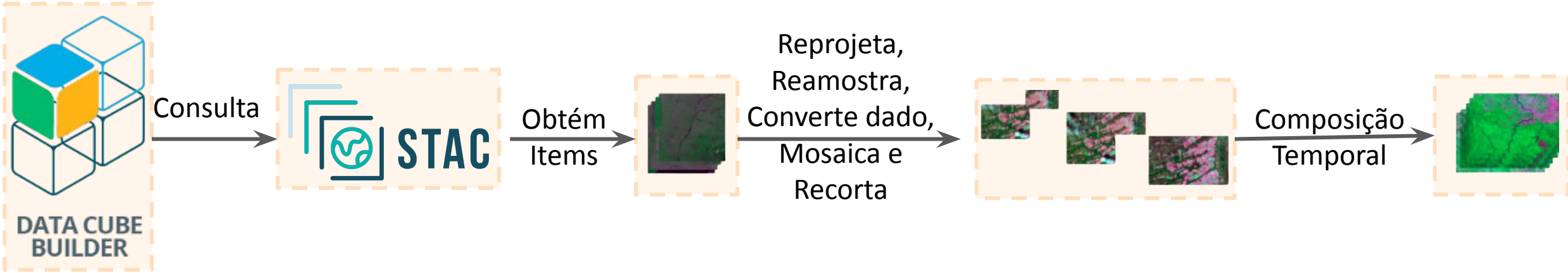
Publicação em banco de dados

Catalog Database

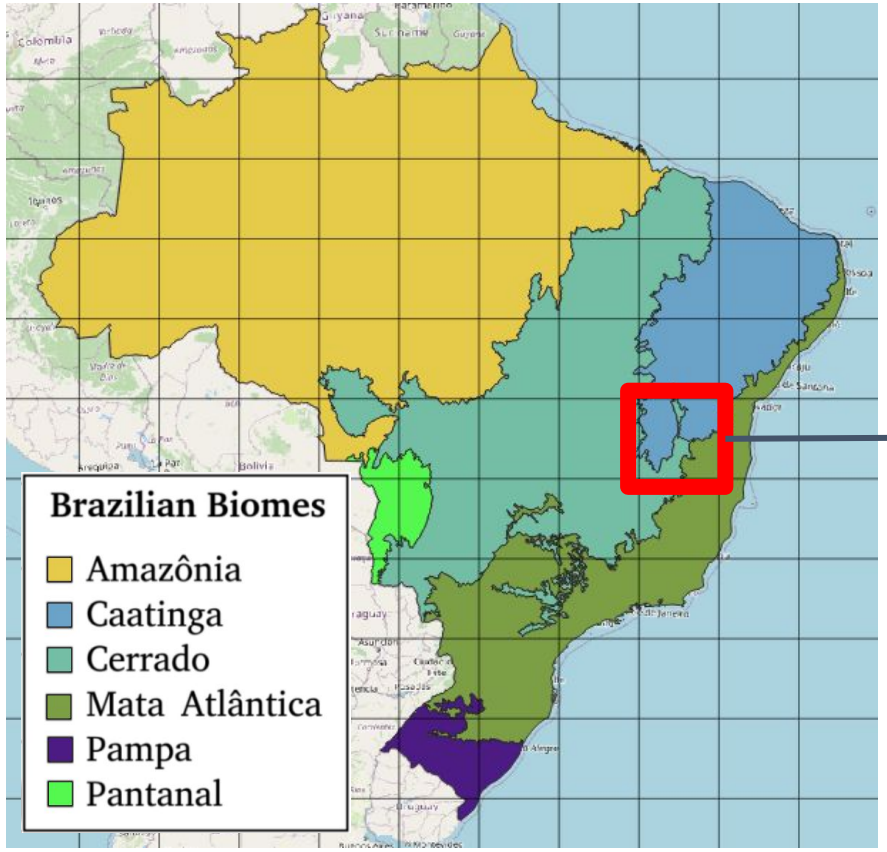
Acesso

STAC

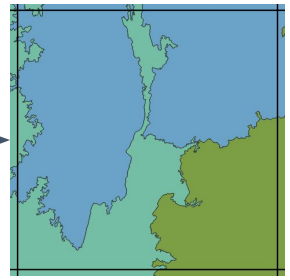
Produção de Cubos de Dados



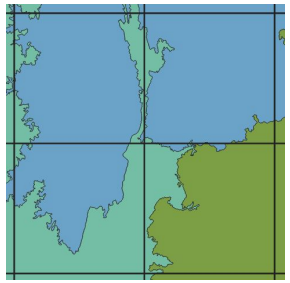
Produção de Cubos de Dados: BDC Grid (V2)



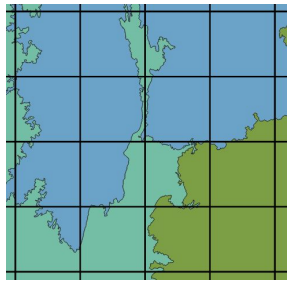
3 grades hierárquicas



Grid: BDC – Large
Tamanho: 422400m x 422400m



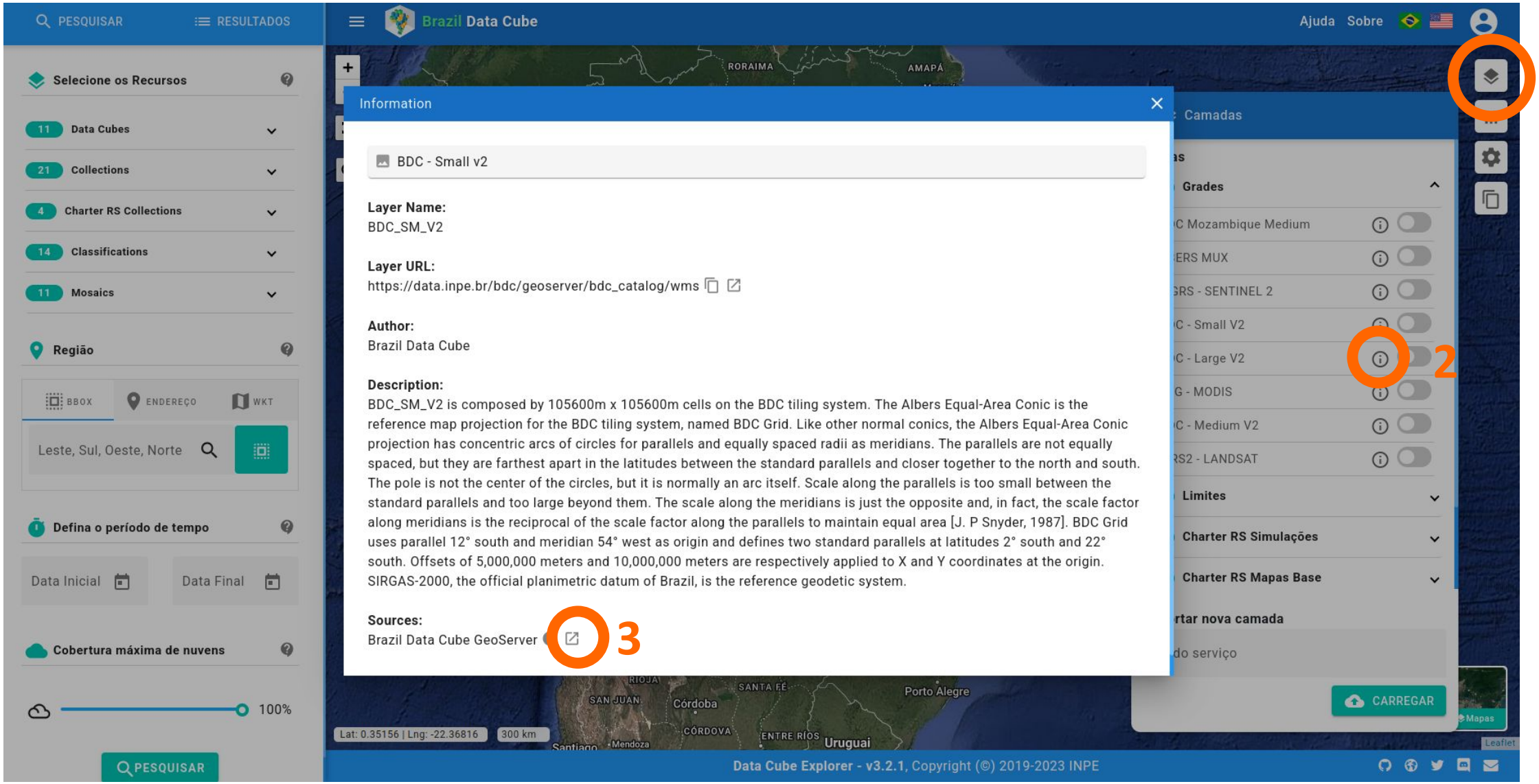
Grid: BDC – Medium
Tamanho: 211200m x 211200m



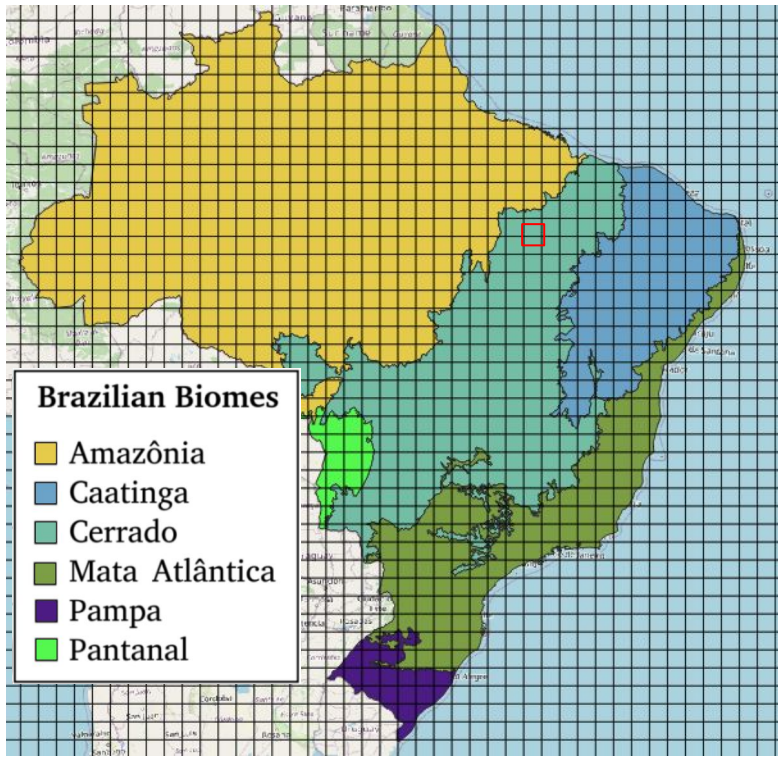
Grid: BDC – Small
Tamanho: 105600m x 105600m

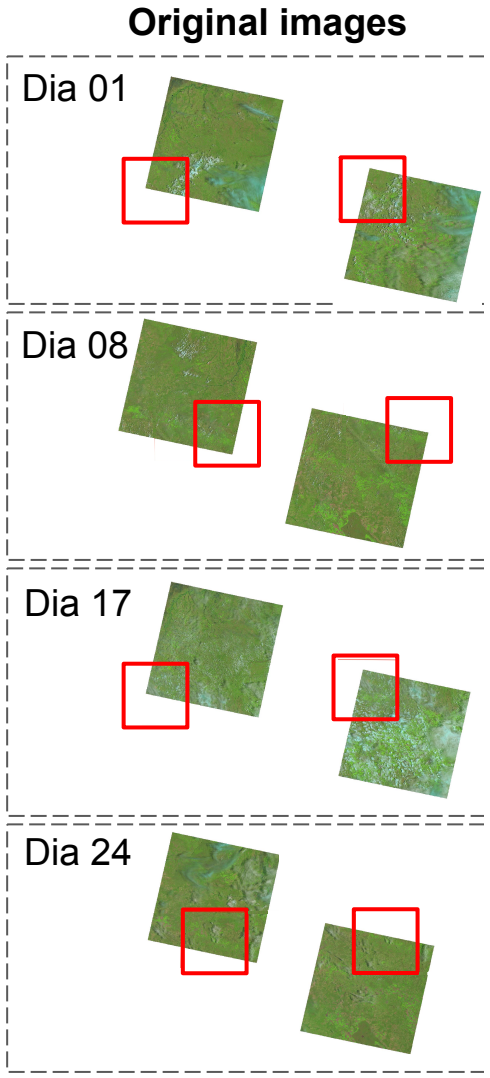
Projection: Albers equal area and Datum: SIRGAS 2000
https://brazil-data-cube.github.io/specifications/bdc-projection.html

Produção de Cubos de Dados: BDC Grid (V2)

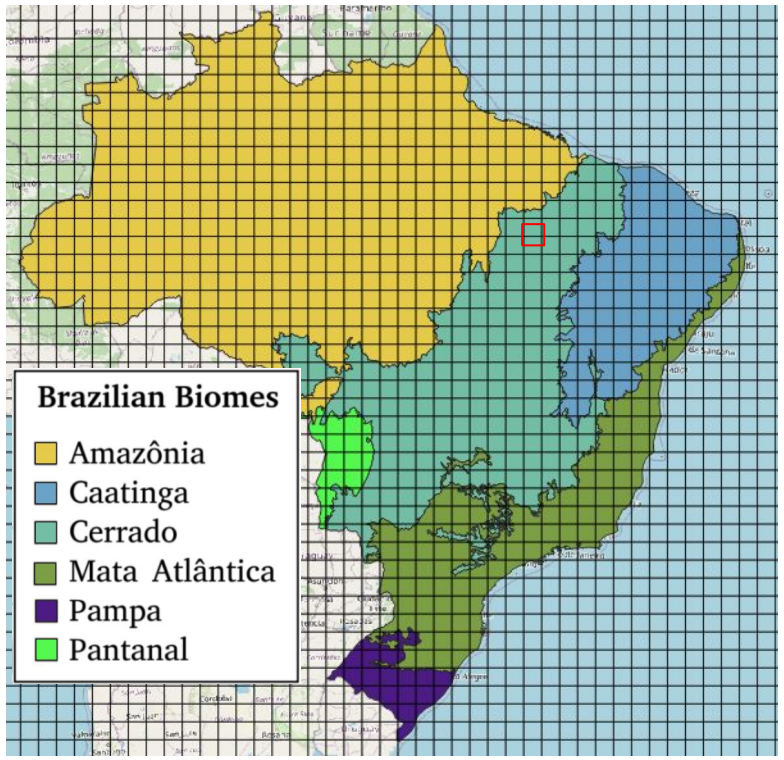


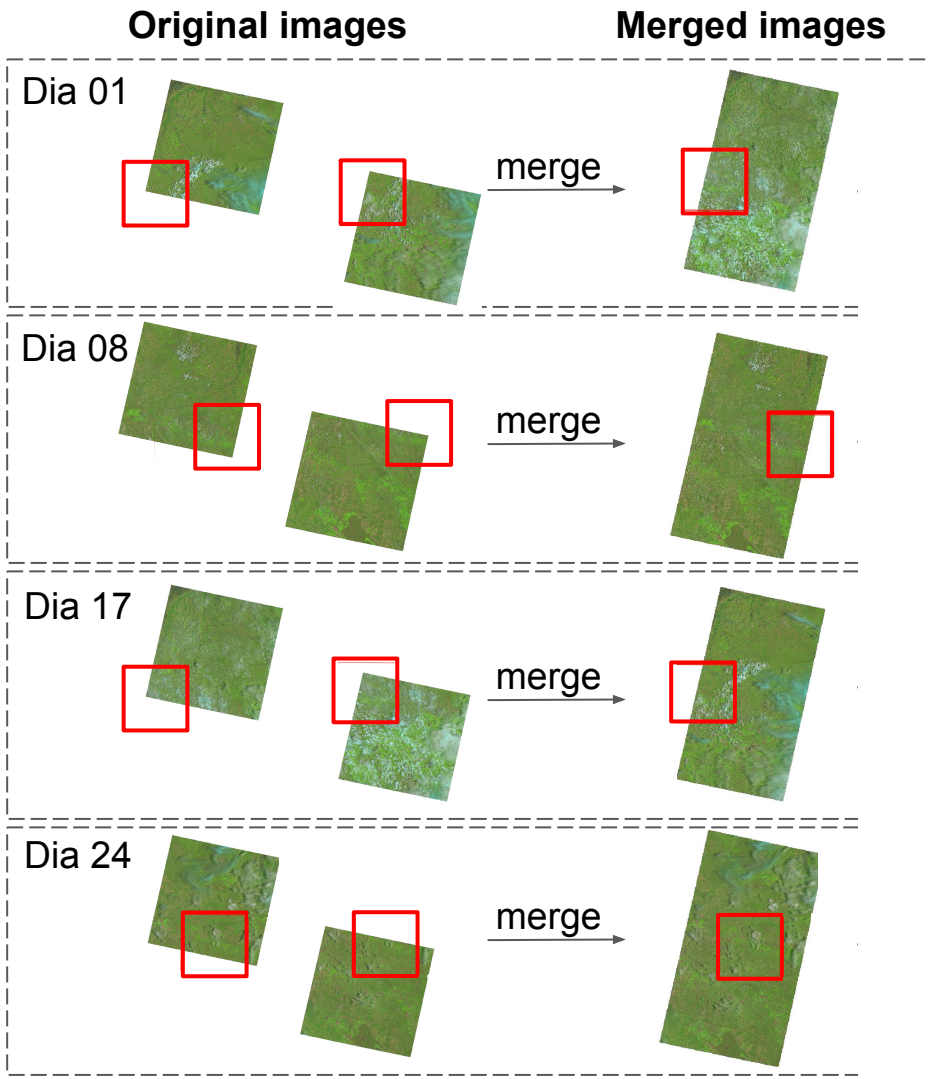
Processamento de Cubo de dados



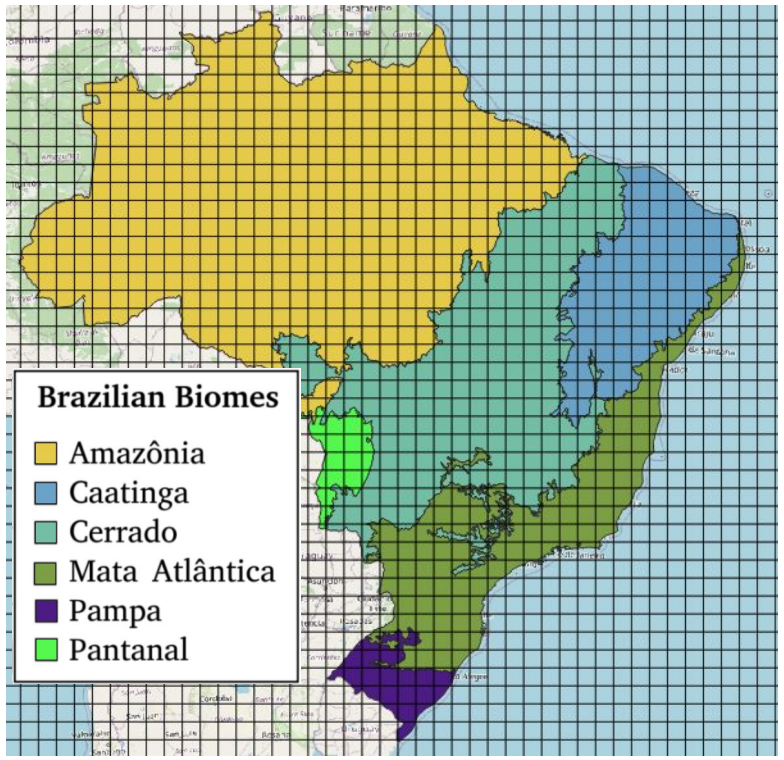


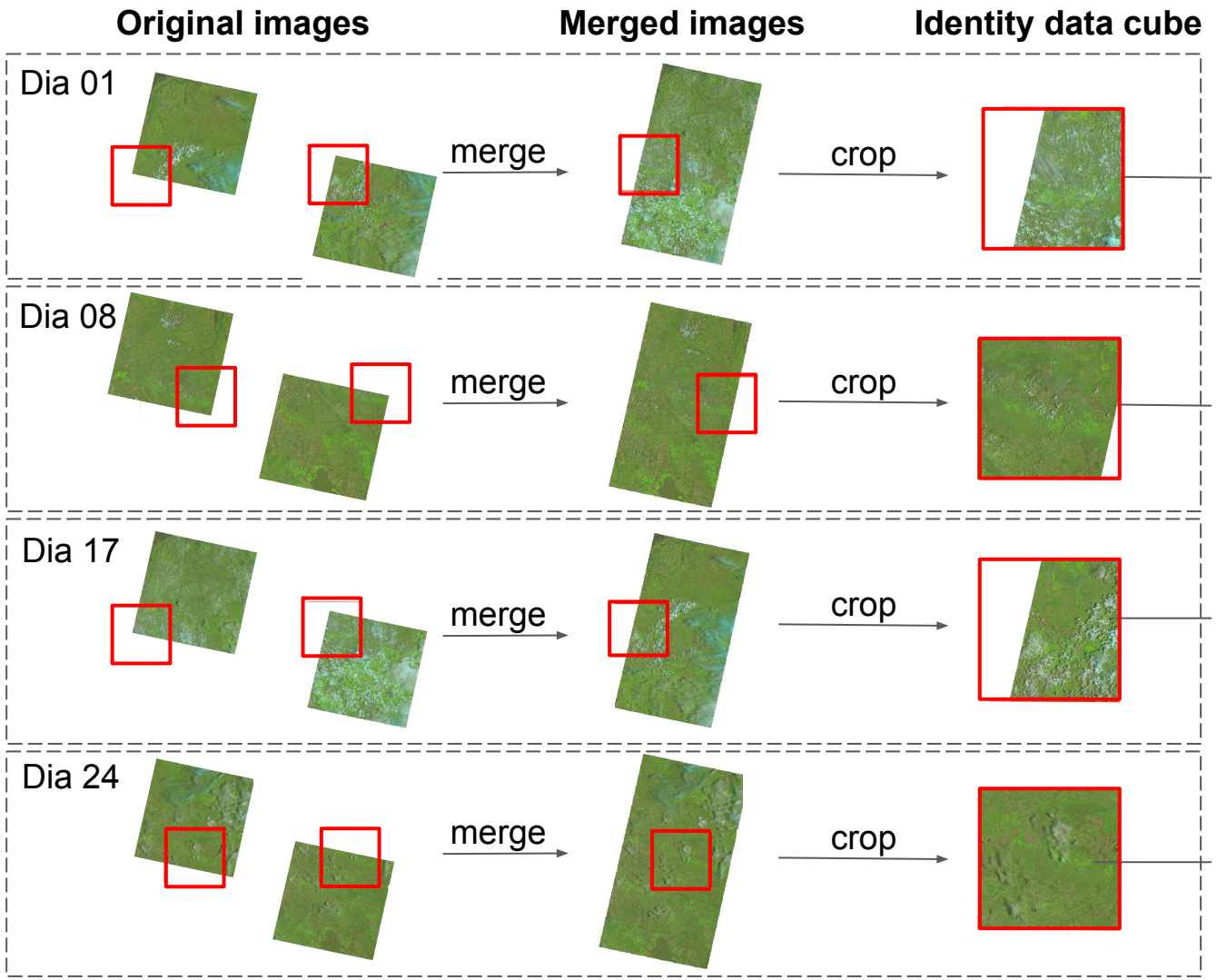
Processamento de Cubo de dados



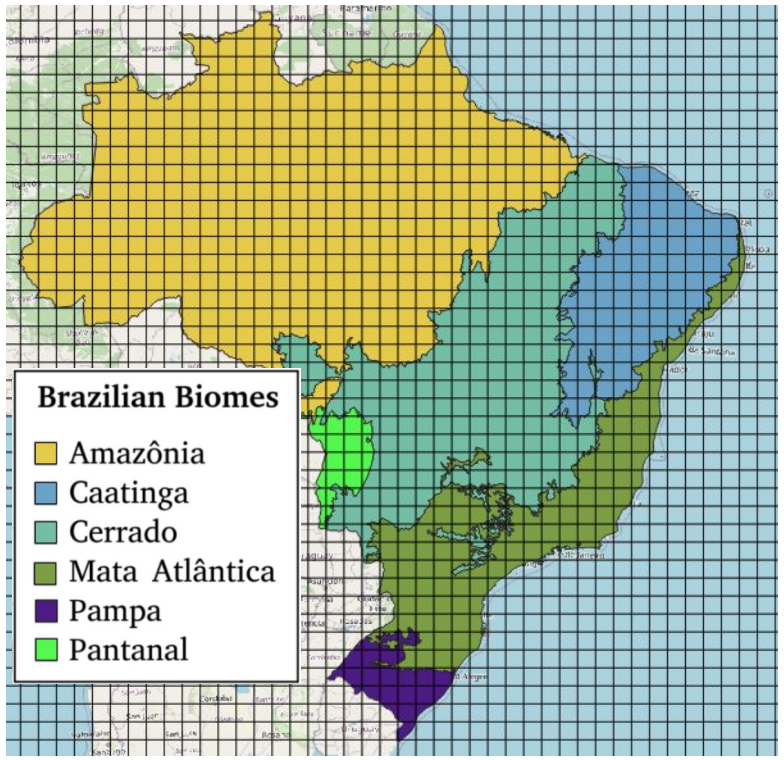


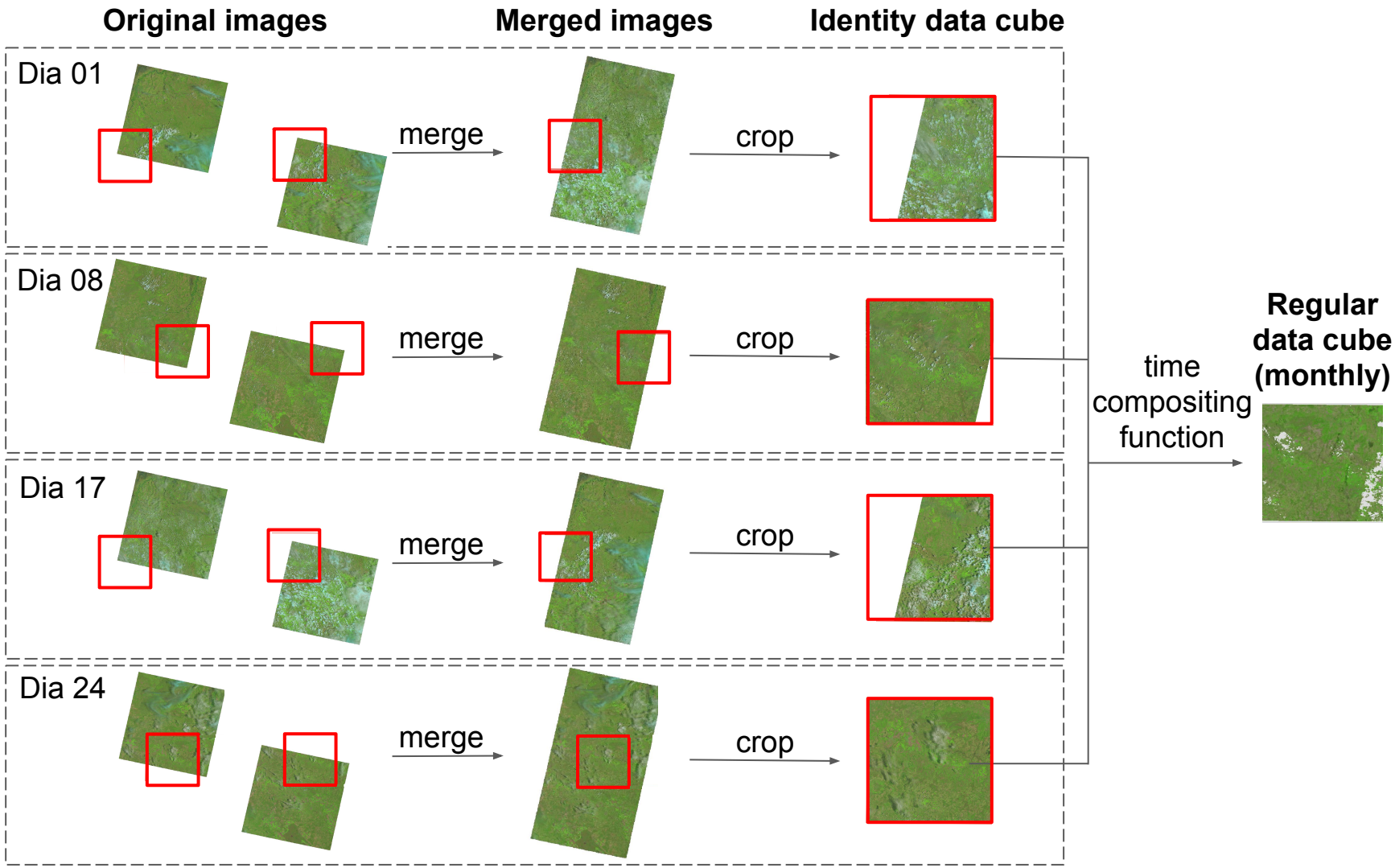
Processamento de Cubo de dados





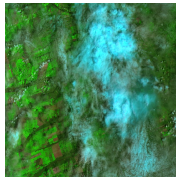
Processamento de Cubo de dados



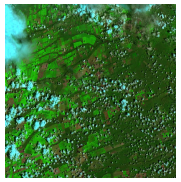


Composição Temporal: Least Cloud Cover First (LCF)

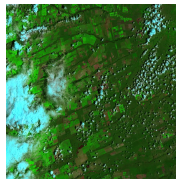
Imagens disponíveis em 16 dias



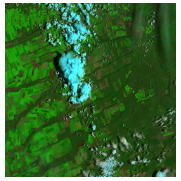
Dia 03
Clear %: 0.5



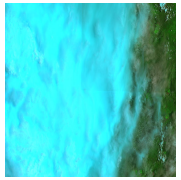
Dia 06
Clear %: 0.7



Dia 09
Clear %: 0.6



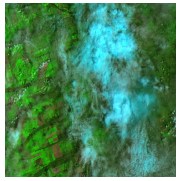
Dia 12
Clear %: 0.8



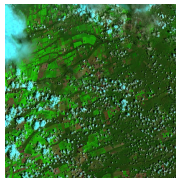
Dia 15
Clear %: 0.1

Composição Temporal: Least Cloud Cover First (LCF)

Imagens disponíveis em 16 dias



Dia 03
Clear %: 0.5



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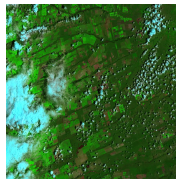

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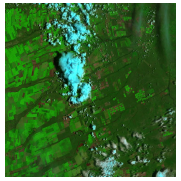
Clear %: 0.6



Dia 12
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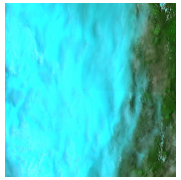


Dia 15
Clear %: 0.1

Sentinel-2 SCL
(Scene Classification Layer)

Label	Classification
0	NO_DATA
1	SATURATED_OR_DEFECTIVE
2	DARK_AREA_PIXELS
3	CLOUD_SHADOWS
4	VEGETATION
5	NOT_VEGETATED
6	WATER
7	UNCLASSIFIED
8	CLOUD_MEDIUM_PROBABILITY
9	CLOUD_HIGH_PROBABILITY
10	THIN_CIRRUS
11	SNOW

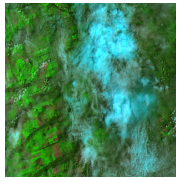
Clear { 4, 5, 6

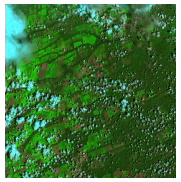
CBERS-4 CMASK

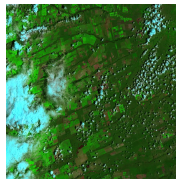
CMask	Descrição
0	clear land pixel
-	clear water pixel
-	cloud shadow
-	snow
4	cloud
255	no observation

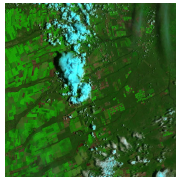
Composição Temporal: Least Cloud Cover First (LCF)

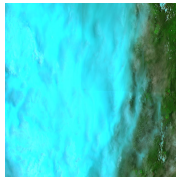
Imagens disponíveis em 16 dias


Dia 03
Clear %: 0.5


Dia 06
Clear %: 0.7

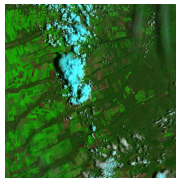

Dia 09
Clear %: 0.6

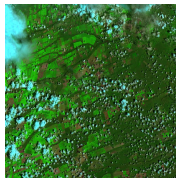

Dia 12
Clear %: 0.8

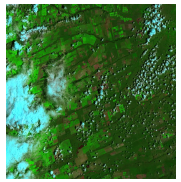

Dia 15
Clear %: 0.1

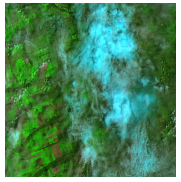
Ordenação

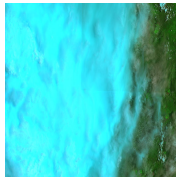
Imagens Ordenadas pelo Clear %


Dia 12
Clear %: 0.8

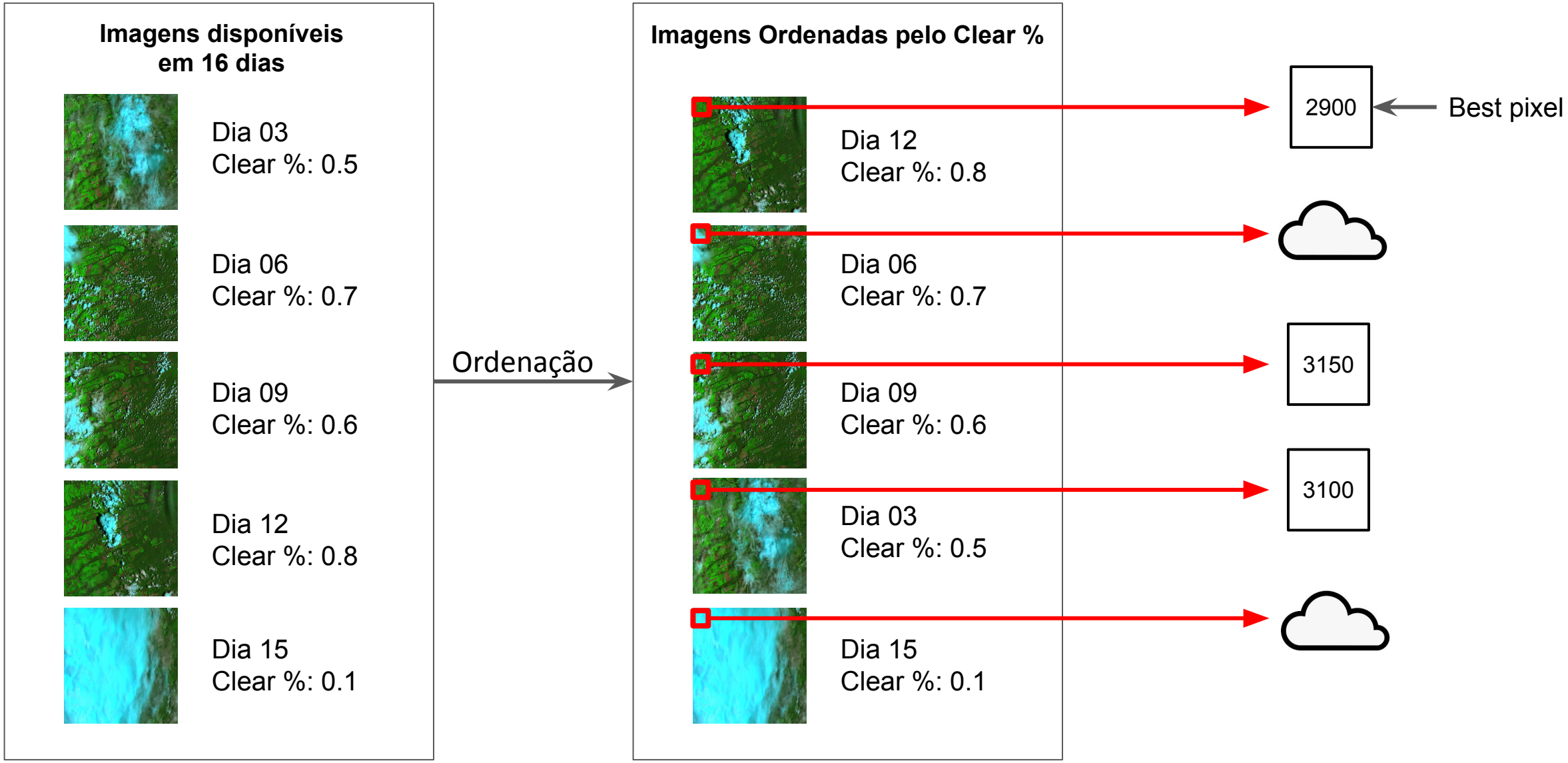

Dia 06
Clear %: 0.7


Dia 09
Clear %: 0.6

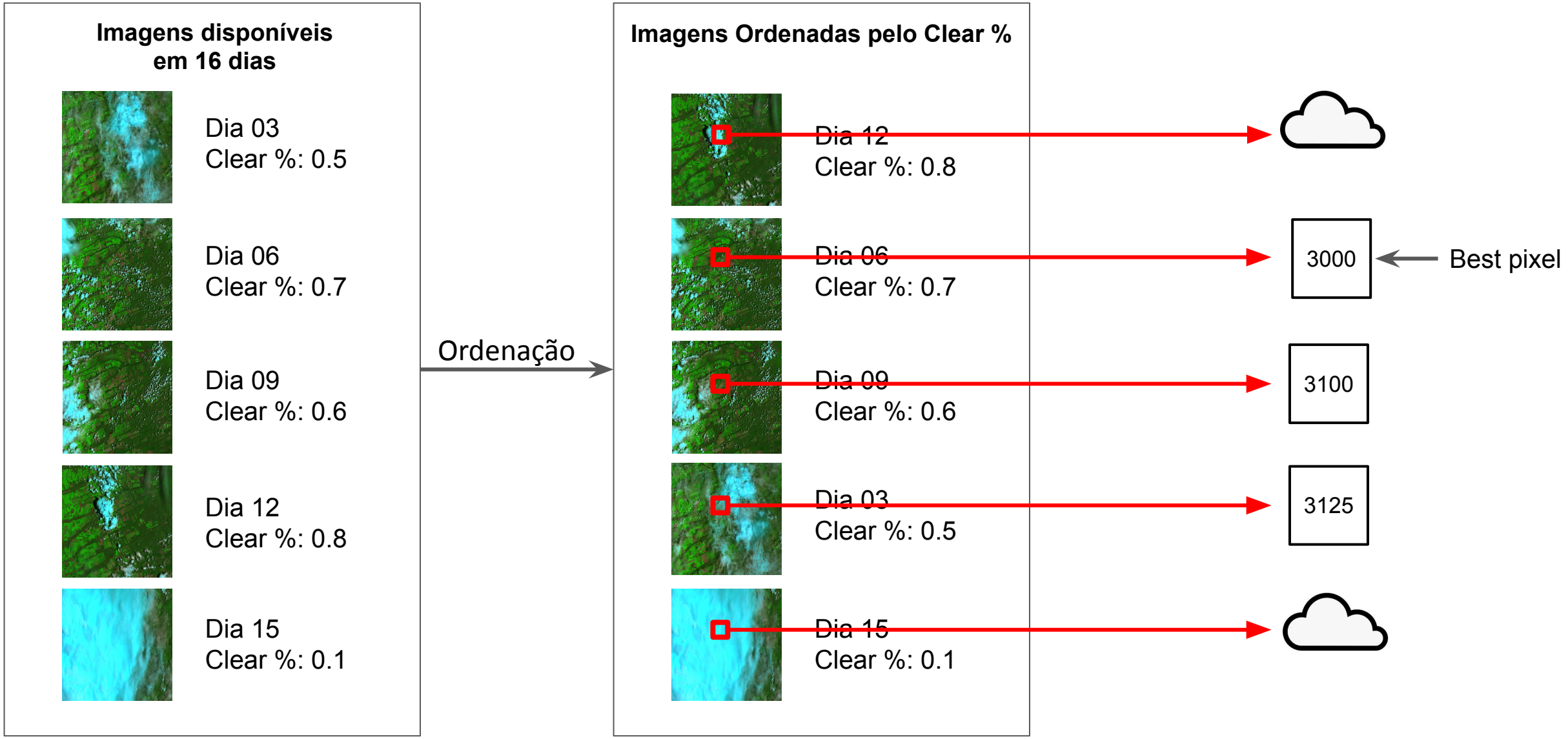

Dia 03
Clear %: 0.5


Dia 15
Clear %: 0.1

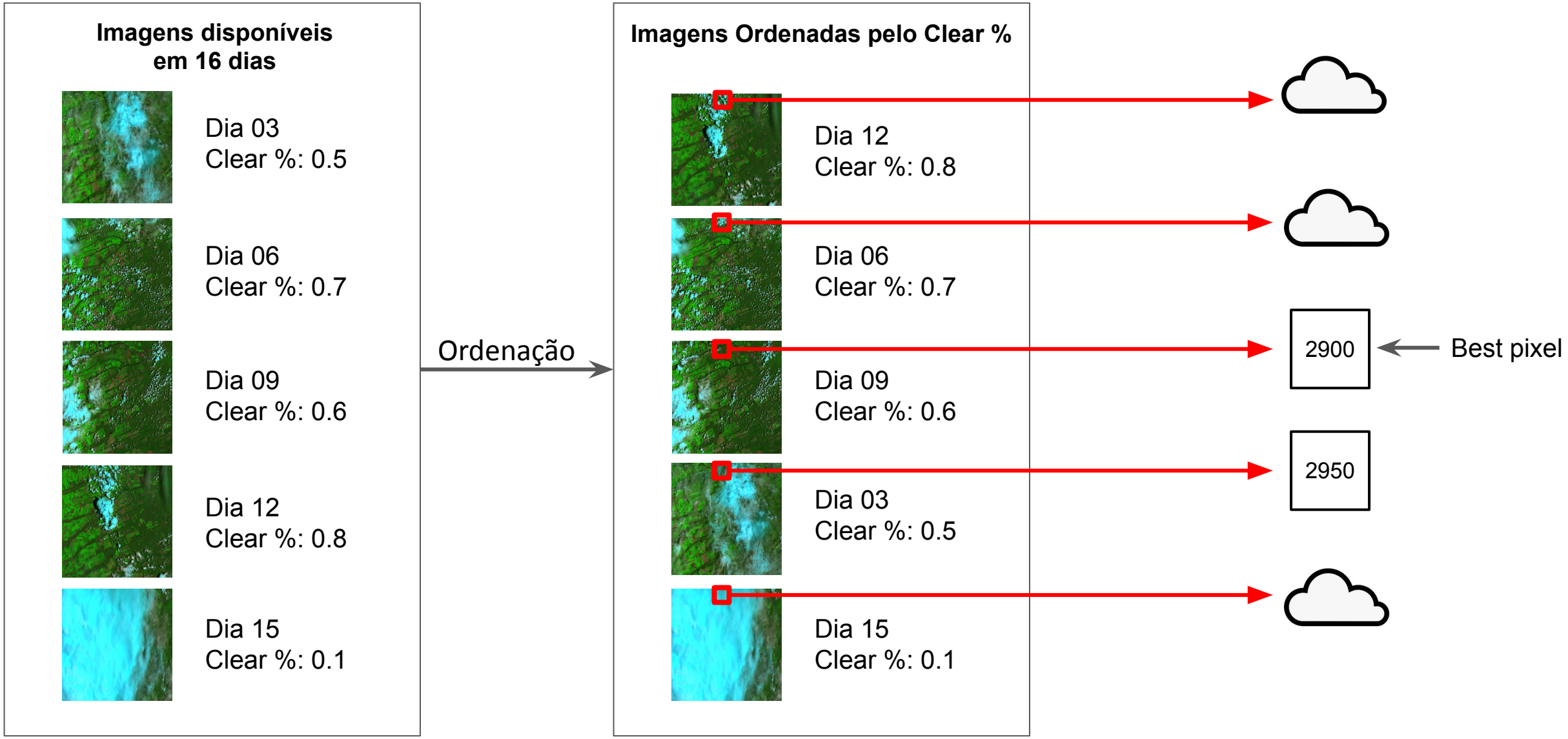
Composição Temporal: Least Cloud Cover First (LCF)



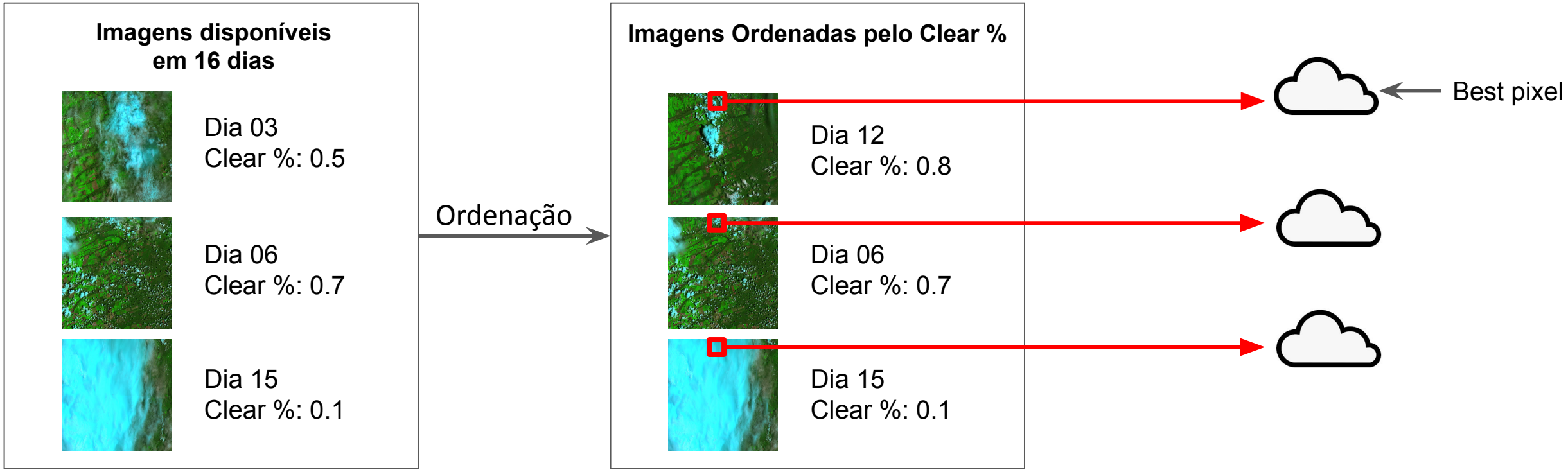
Composição Temporal: Least Cloud Cover First (LCF)



Composição Temporal: Least Cloud Cover First (LCF)

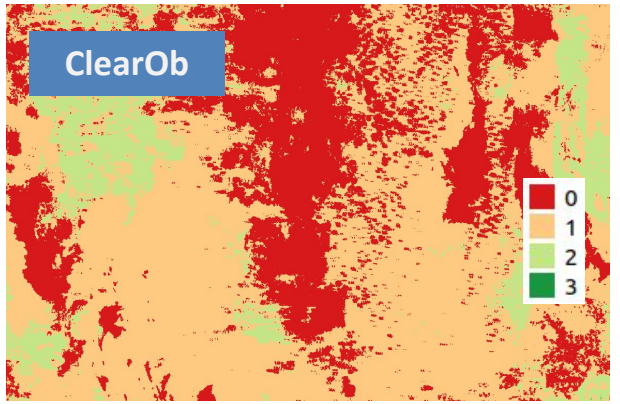


Composição Temporal: Least Cloud Cover First (LCF)

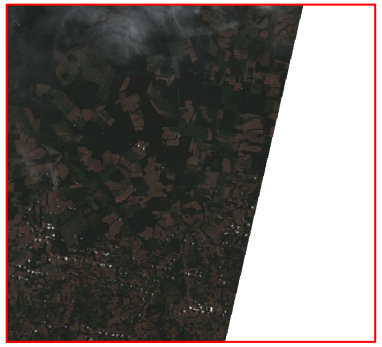


Bandas dos Cubos de Dados

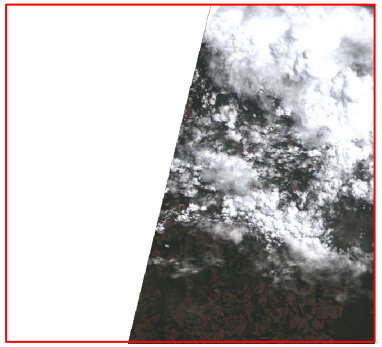
	Attributes	Description
Spectral Bands	Surface reflectance bands	Images processed as surface reflectance level
Extras Bands	Provenance	Day of the year indicating the source image sensing date
	ClearOb	Number of Clear Observations (No cloud, or Cloud Shadow) in the temporal compositing period.
	TotalOb	Total Number of Observation in the temporal compositing period.
	Quality (Cloud Mask)	Cloud, Cloud Shadow and clear observation mask
Spectral Indices	NDVI	Normalized Difference Vegetation Index
	EVI	Enhanced Vegetation Index
	NBR	Normalized Burn Ratio Index



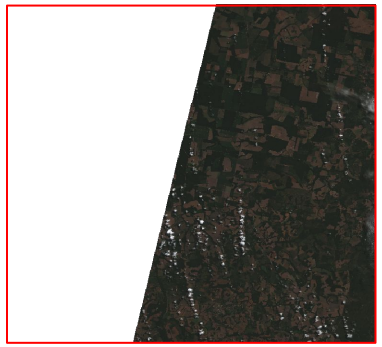
Coleção original vs Cubos de Dados



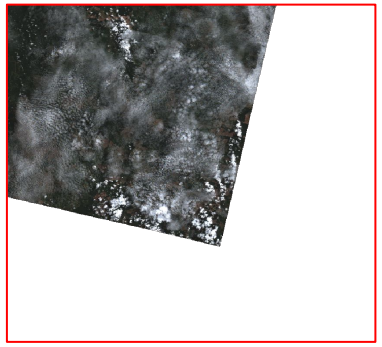
2025-03-18



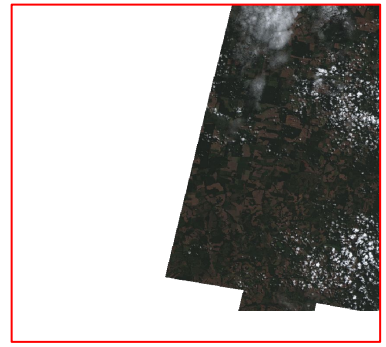
2025-03-20



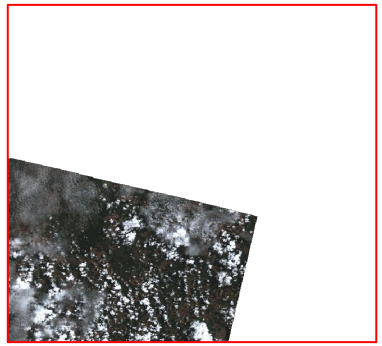
2025-03-22

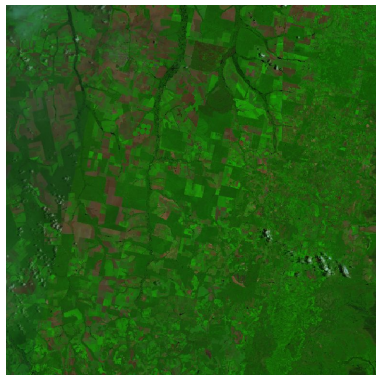


2025-03-23



2025-03-25

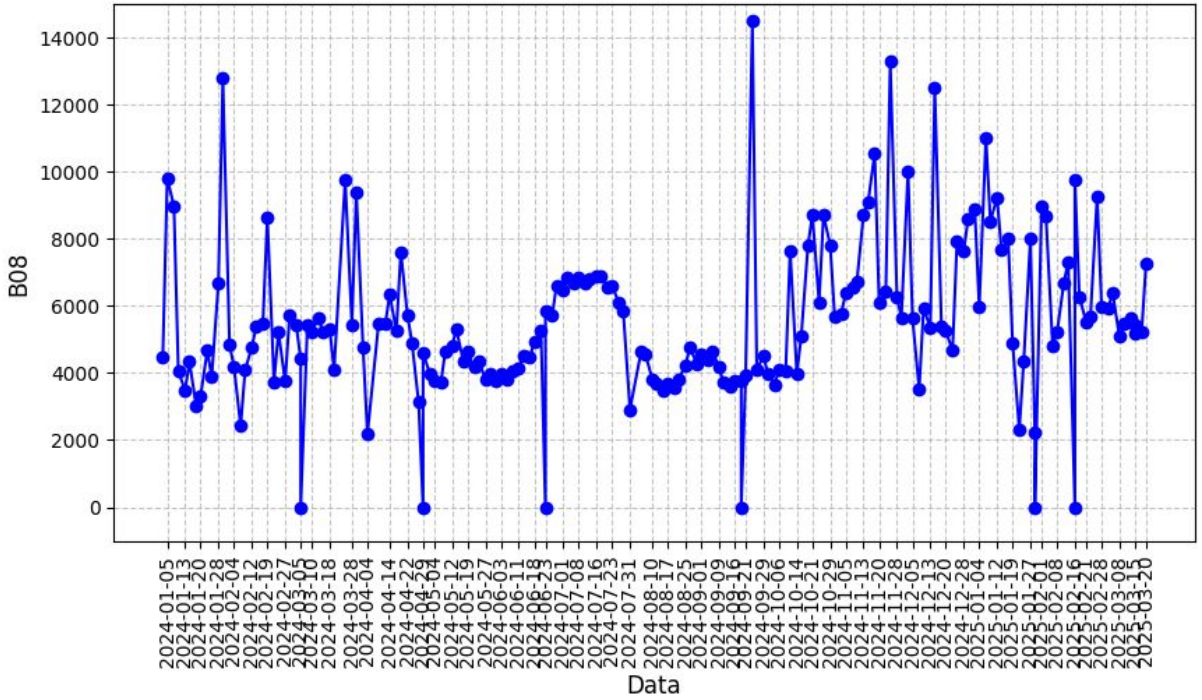




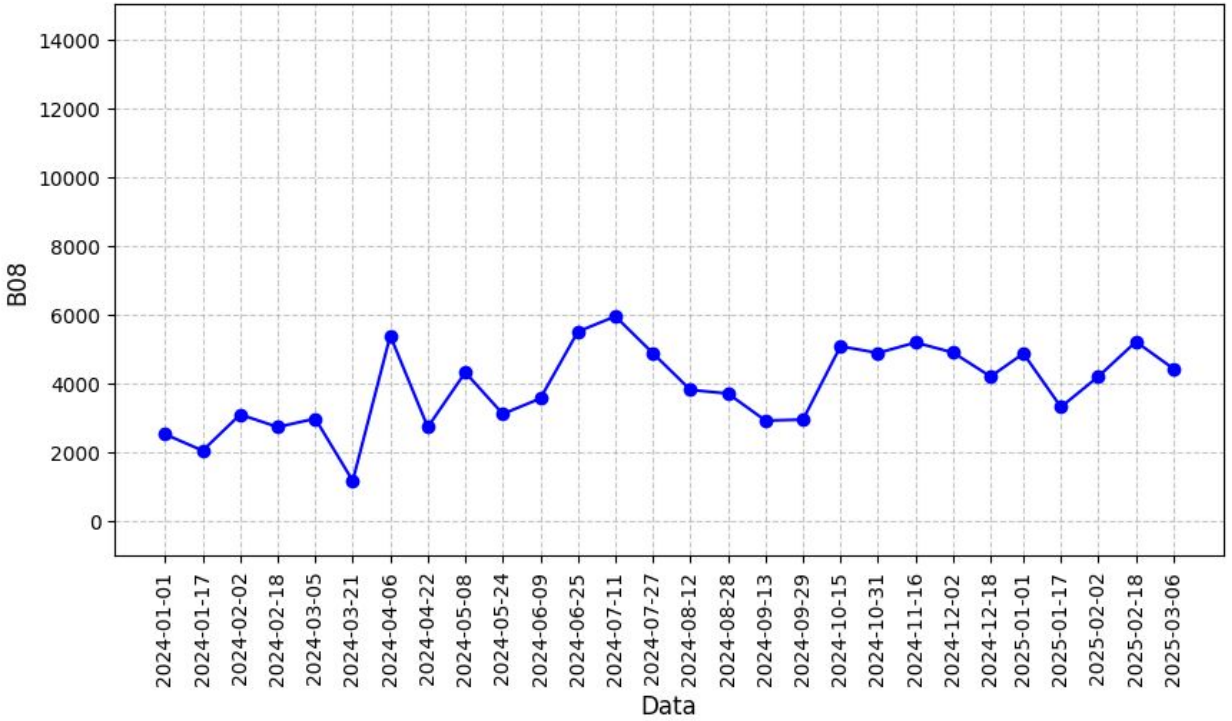
16 dias “agrupados”

Coleção original vs Cubos de Dados

Série dado original



Séries Cubo de dado



Coleções CBERS-4, CBERS-4A and AMAZONIA-1

- CBERS-4/MUX - L4-SR - COG (20 metros)
- CBERS-4/WFI - L4-SR - COG (64 metros)
- CBERS-4A/WFI - L4-SR - COG (55 metros)
- CBERS-4A/WPM - COG Multispectral, Fusioned Pan (2 metros)
- AMAZONIA-1/WFI - L4-SR - COG (64 metros)

Coleções CBERS-4, CBERS-4A and AMAZONIA-1

CBERS-4/MUX - L4-SR - COG (20 metros)

CBERS-4/WFI - L4-SR - COG (64 metros)

CBERS-4A/WFI - L4-SR - COG (55 metros)

CBERS-4A/WPM - COG Multispectral, Fusioned Pan (2 metros)

AMAZONIA-1/WFI - L4-SR - COG (64 metros)

CBERS-4/MUX (20 metros)

CBERS-4/WFI (64 metros)

CBERS-4/WFI (64 metros) + CBERS-4A/WFI (55 metros)

CBERS-4 WFI - Brazil (64 metros)

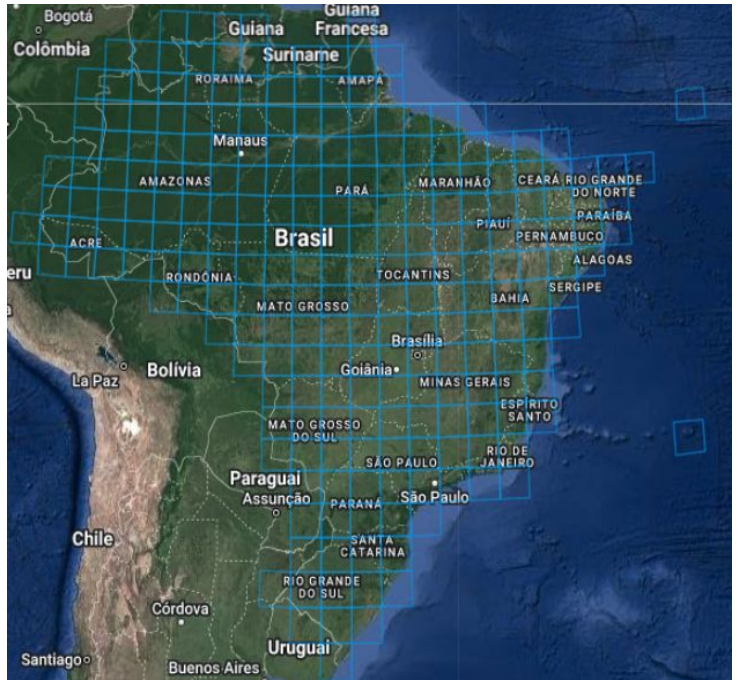
3 meses
[Maio-Junho - 2020]

RGB: B15 - B16 - B13
Resolução: 64m

Coleções Landsat

Landsat Collection 2 - Level-2
(30 metros)

Landsat-5/TM (30 metros)
Landsat-7/ETM+ (30 metros)
Landsat-8/OLI (30 metros)
Landsat-9/OLI2 (30 metros)



Landsat-8 - OLI - Brazil
(30 metros)

6 meses
[Julho-Dez. - 2017]

RGB: B6 -B5 - B4
Resolução: 30m

USGS
science for a changing world

Coleções Sentinel-1, Sentinel-2, Sentinel-3

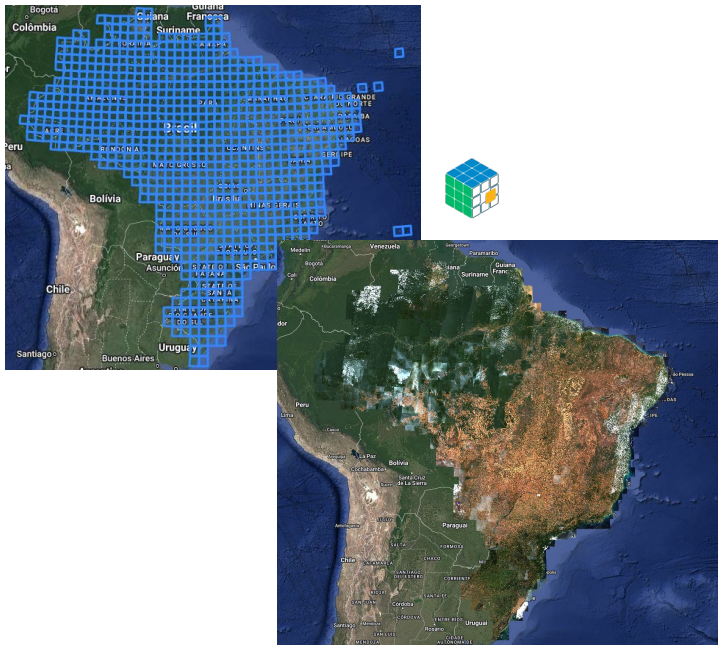
Sentinel-1 - Level-1 - GRD

Sentinel-2 - Level-1C - Bundle

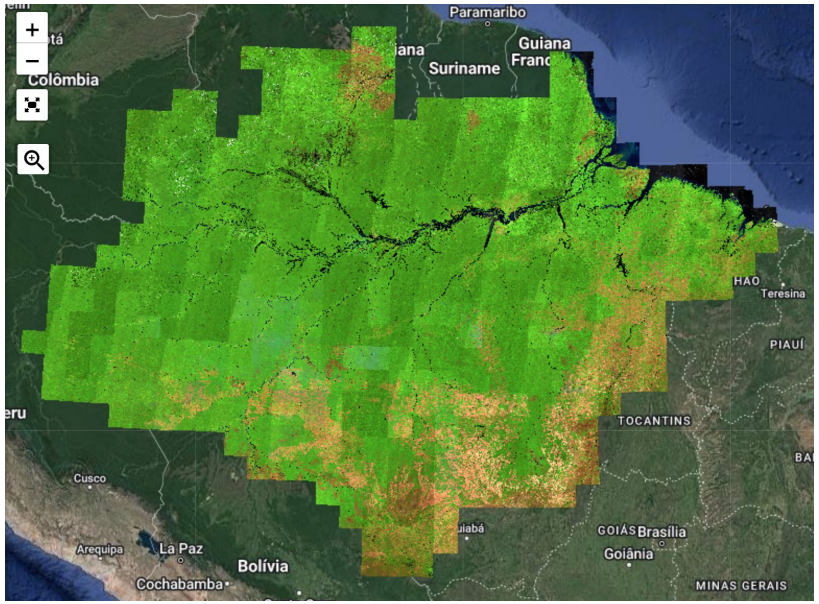
Sentinel-2 - Level-2A - Bundle

Sentinel-2 - Level-2A - COG

Sentinel-3/OLCI - Level-1B Full Resolution



Sentinel-2/MSI - Level-2A - Data Cube - LCF 16 days (10 metros)



3 meses
[Junho-Ago. - 2022]

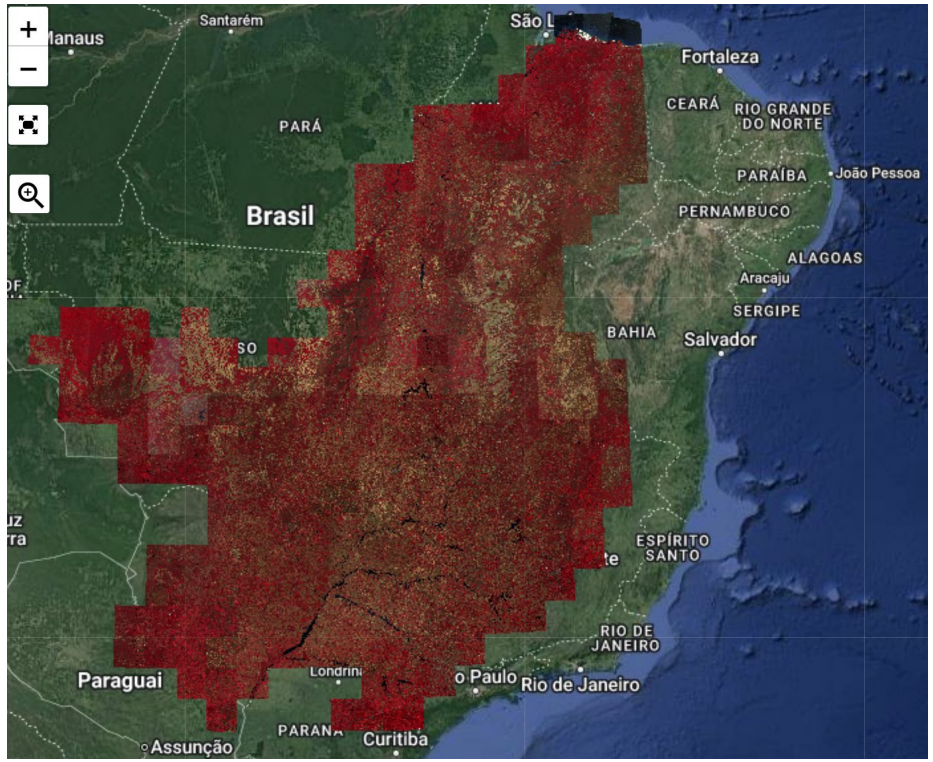
RGB: B11, B8A, B04
Resolução: 10m

Sentinel-2 - MSI - Amazonia (10 metros)

Mais exemplos de Mosaicos Sentinel-2

Sentinel-2 - MSI - Cerrado (10 metros)

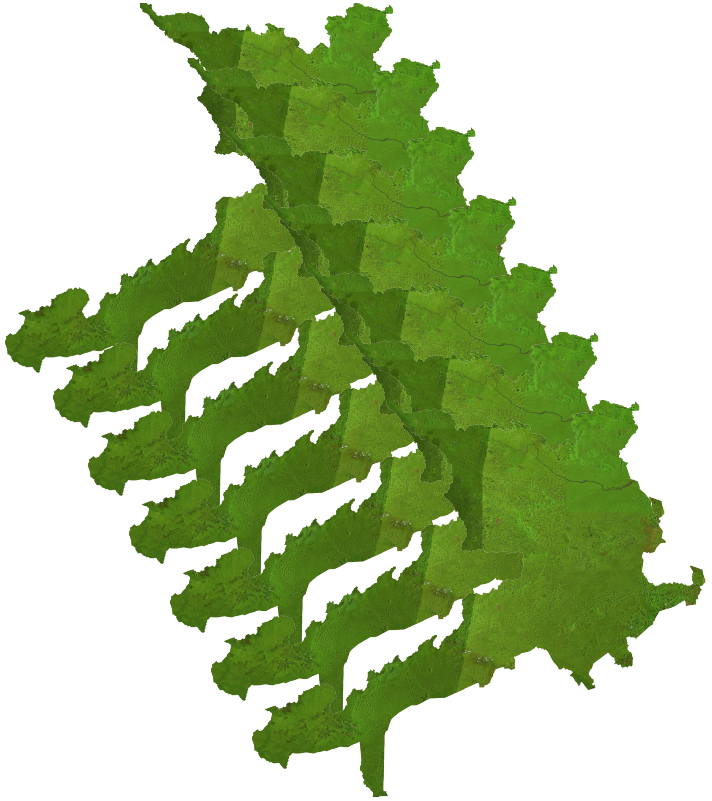
4 meses
[Junho-Set. - 2022]



RGB: B08, B04, B03
Resolução: 10m

Sentinel-2 - MSI - Yanomami Reserve (10 metros)

6 meses
[Abril (2019) - Abril (2022)]
(7 mosaicos de 6 meses)



RGB: B11, B08, B04
Resolução: 10m

Coleções MODIS

TERRA/MODIS (MOD13Q1) (250 metros)

Time Step: 16 dias
Timeline: 2000 - 2025*
Grid: STG

AQUA/MODIS (MYD13Q1) (250 metros)

Time Step: 16 dias
Timeline: 2002 - 2025*
Grid: STG

TERRA/MODIS (MOD11A2) (1 km)

Time Step: 8 dias
Timeline: 2000 - 2025*
Grid: STG

AQUA/MODIS (MYD11A2) (1 km)

Time Step: 8 dias
Timeline: 2002 - 2025*
Grid: STG

Coleções GOES

GOES-13/Imager - Level-3 - VIS/IR Imagery (Binary)

Timeline: 25/11/2011 - 01/08/2018

GOES-16 Cloud & Moisture Imagery

Timeline: 03/04/2019 - 2025

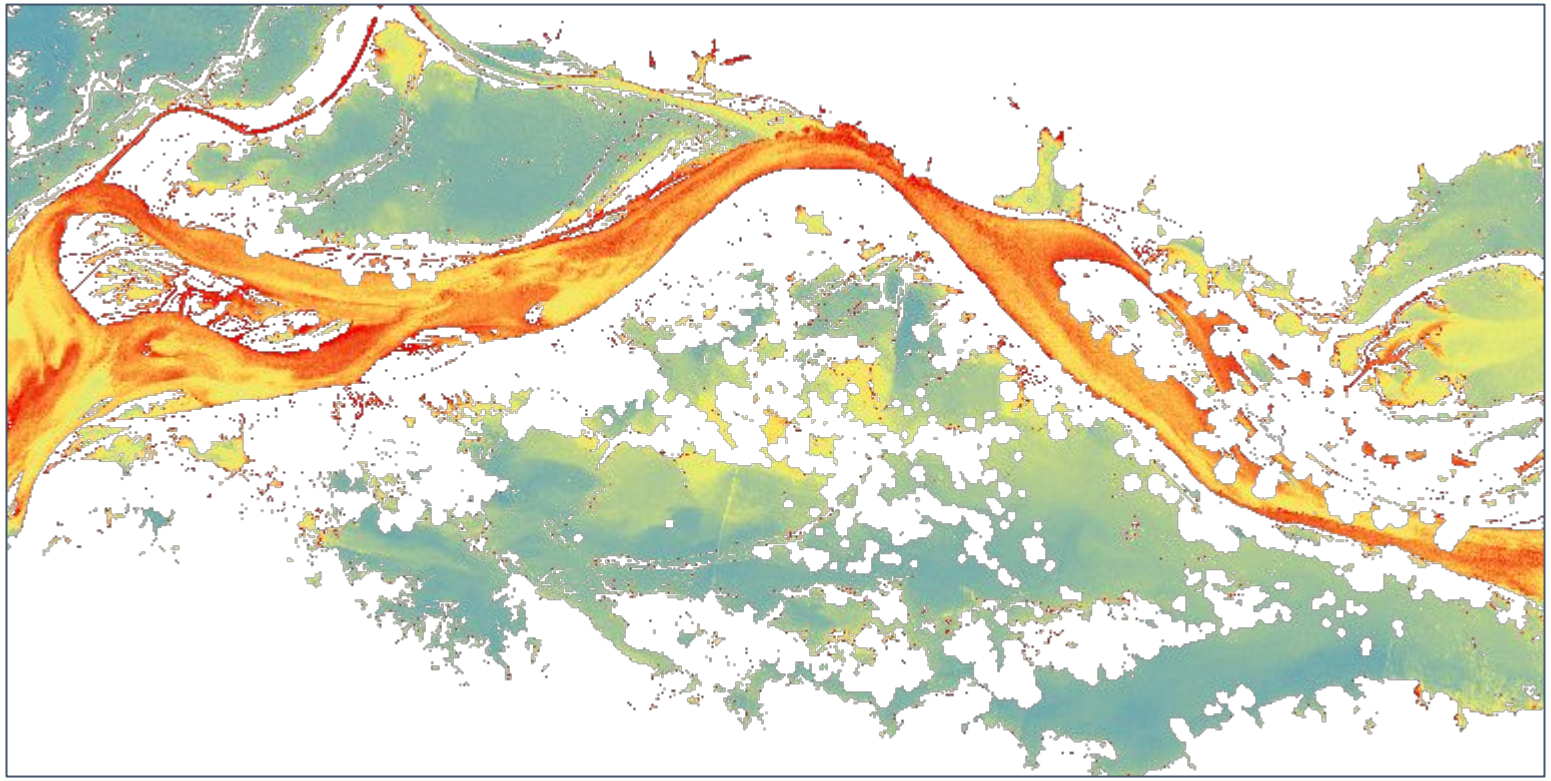
GOES-19 Cloud & Moisture Imagery

Timeline: 2025

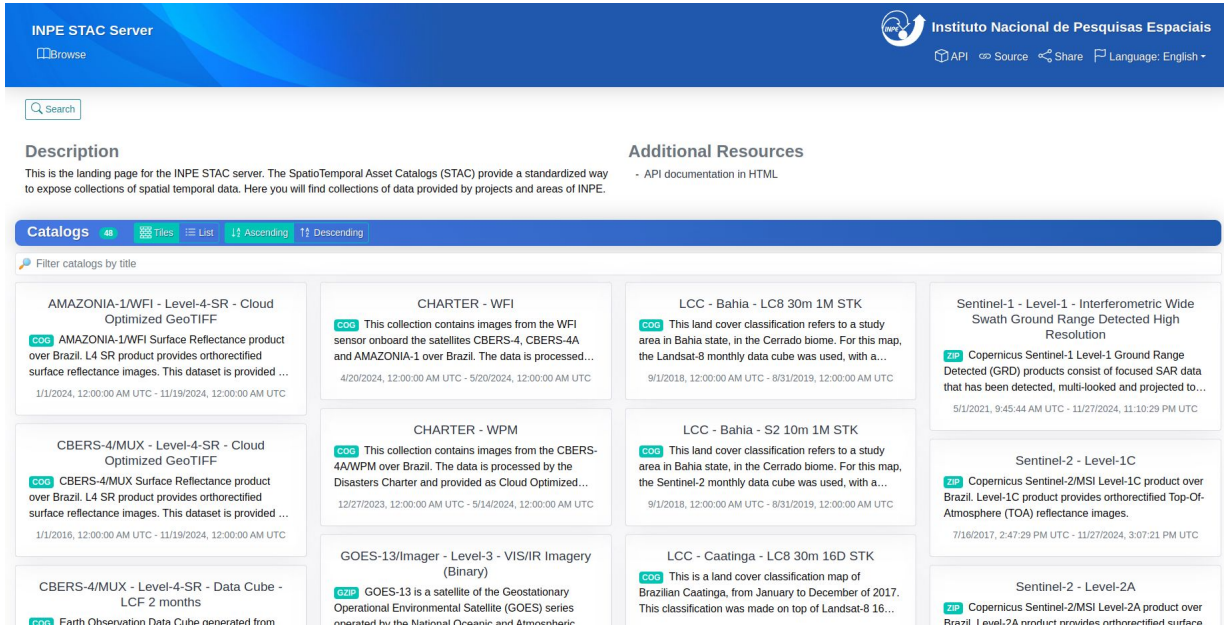
Coleções Classificações de uso e cobertura da Terra

15 Classifications

- KD - Curuai - Sentinel-2 ...
- LCC - Goias - CB4_64_1M_S...
- LCC - Mato Grosso - CB4_6...
- LCC - Mato Grosso - CB4_6...
- LCC - Bahia - CB4_64_1M_S...
- LCC Landsat-8 16D STK Ama...
- LCC Landsat-8 16D STK Caa...
- LCC Landsat-8 16D STK Cer...
- LCC Landsat-8 16D STK Mat...
- LCC Landsat-8 16D STK Pam...
- LCC Landsat-8 16D STK Pan...
- LCC Landsat-8 1M STK Cerr...
- LCC - Bahia - LC8_30_1M_S...
- LCC Sentinel-2 16D STK Am...
- LCC - Bahia - S2_10_1M_ST...



Links úteis



STAC **Browser**

https://data.inpe.br/stac/browser

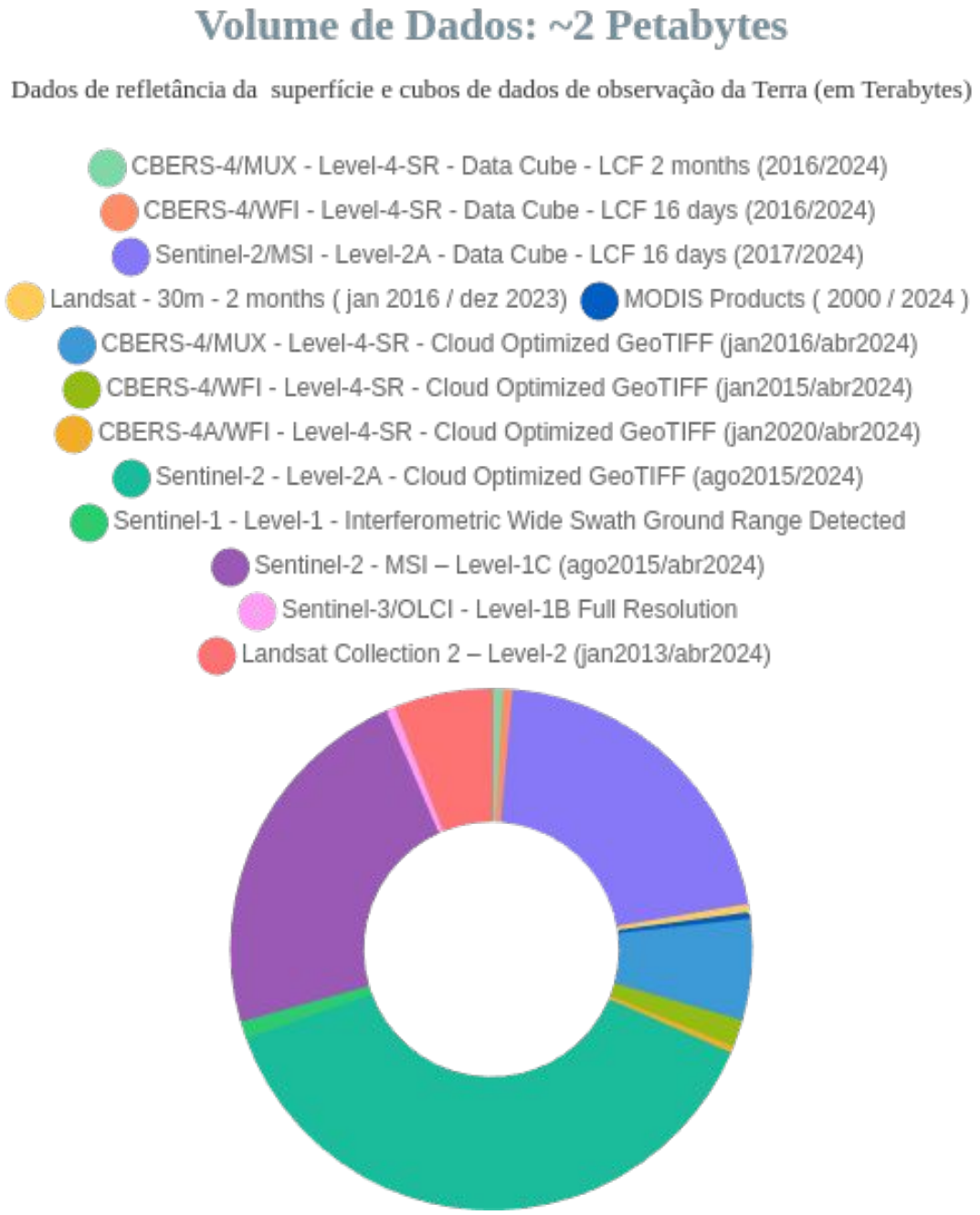
BDC **Explorer**

https://data.inpe.br/bdc/explorer

INPE **STAC** https://data.inpe.br/bdc/stac/v1/

QGIS Plugin

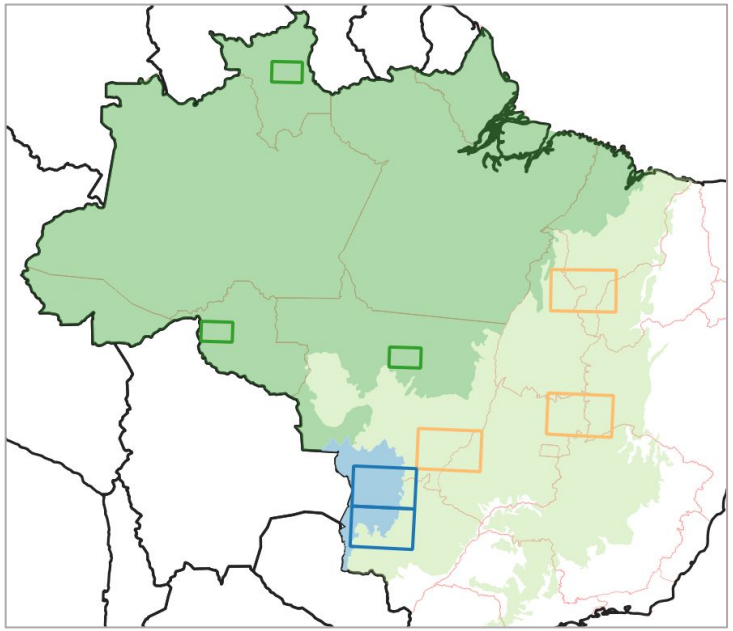
Desafio - Big data

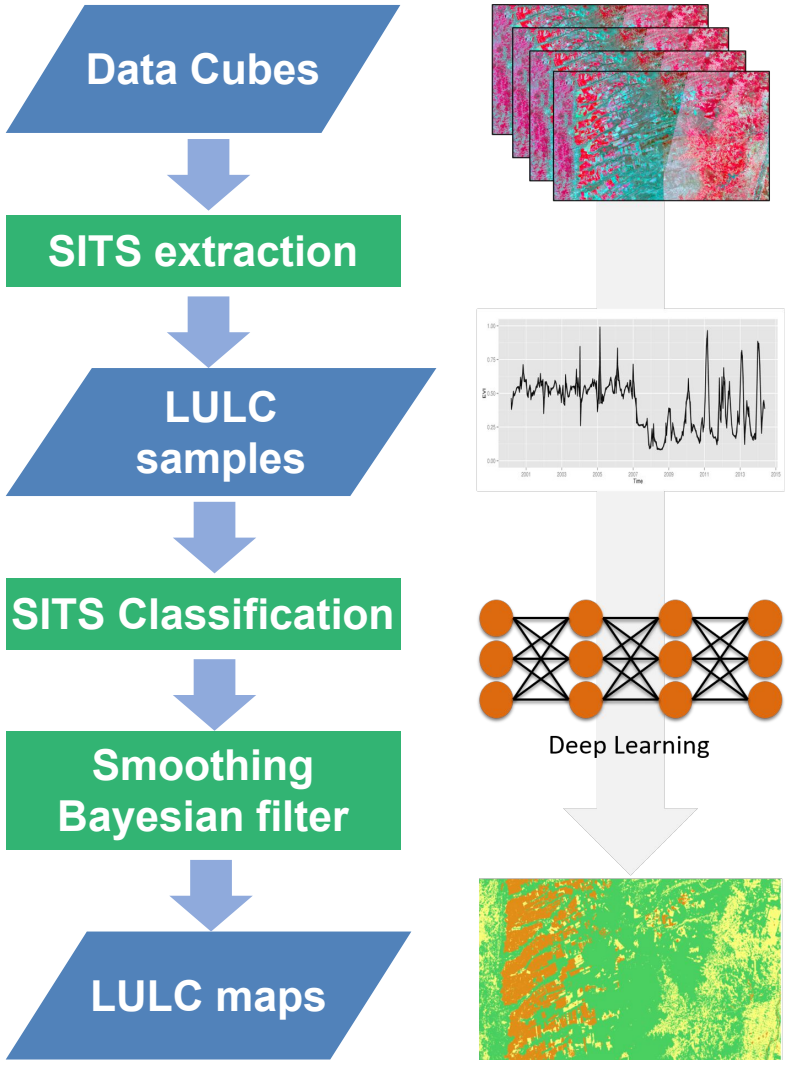


Além dos dados: A plataforma Brazil Data Cube

Técnologias de Big data, análises de séries temporais e métodos de aprendizagem de máquina.

Classificação de uso e cobertura da Terra





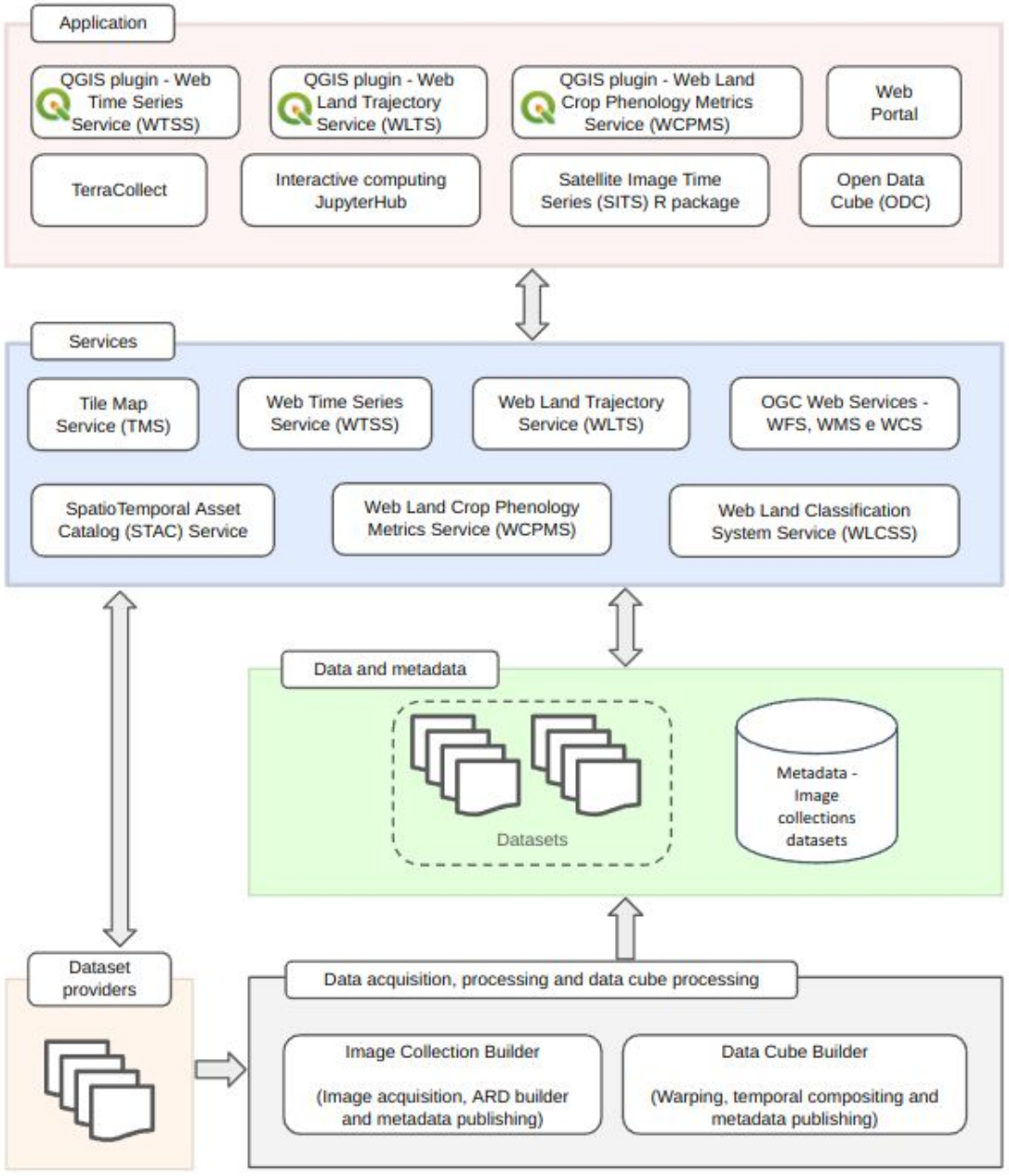
Source: [Ferreira et al, 2020]

BRAZIL
DATA CUBE

Open Data and Software Products

Software

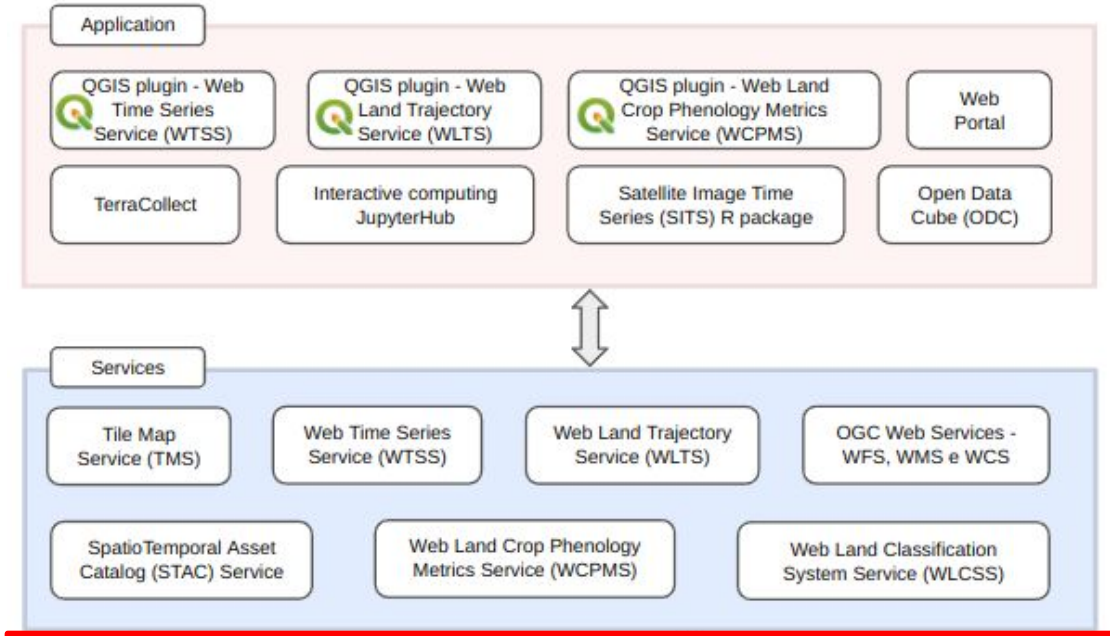
Dados e metadados



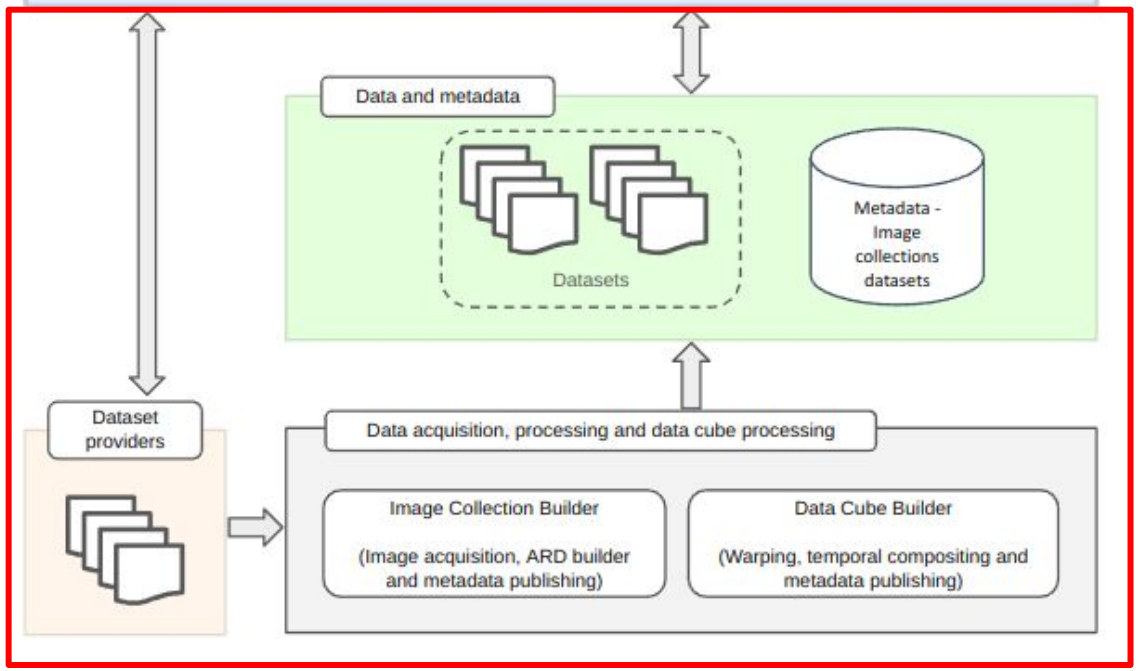
BRAZIL
DATA CUBE

Open Data and Software Products

Software

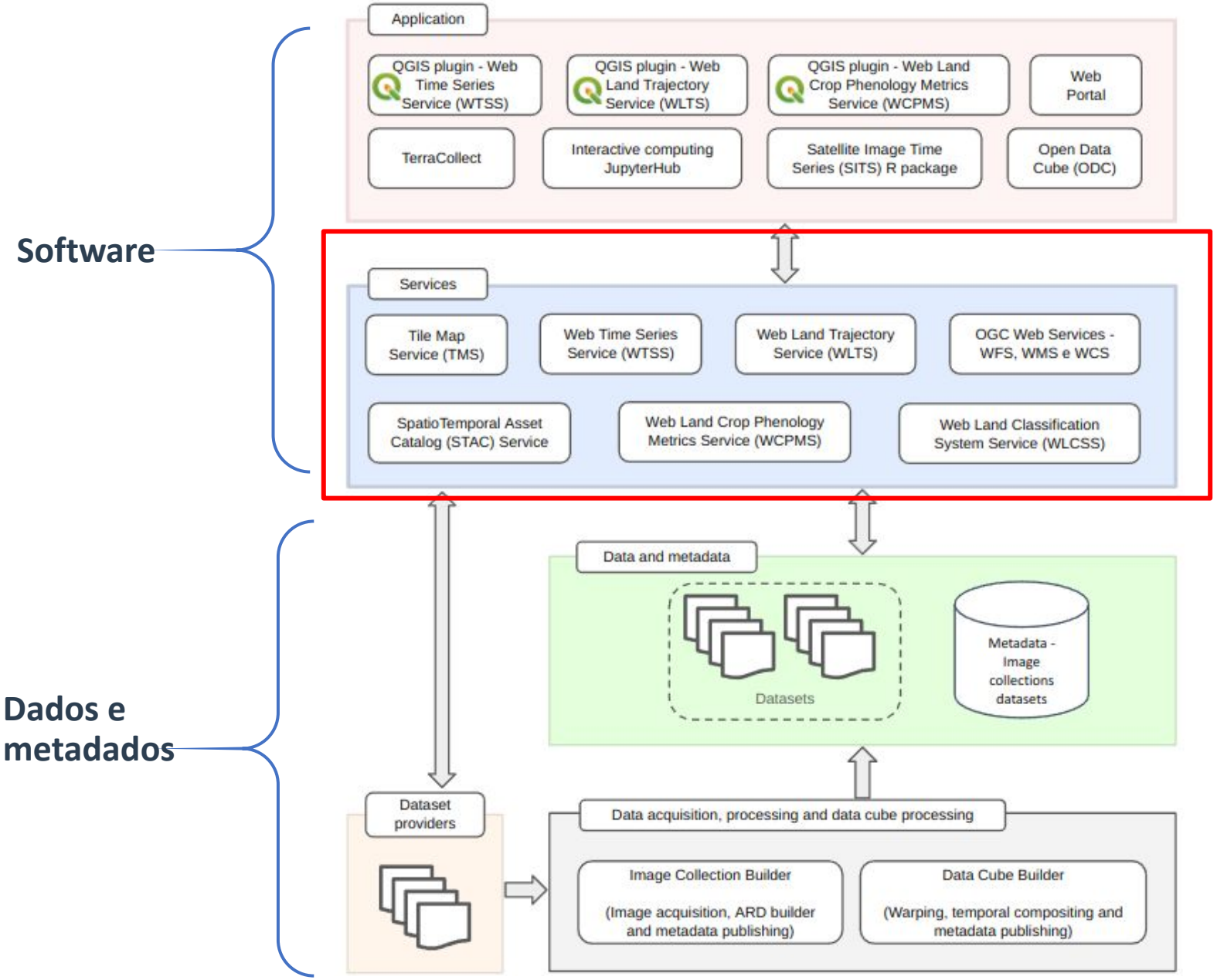


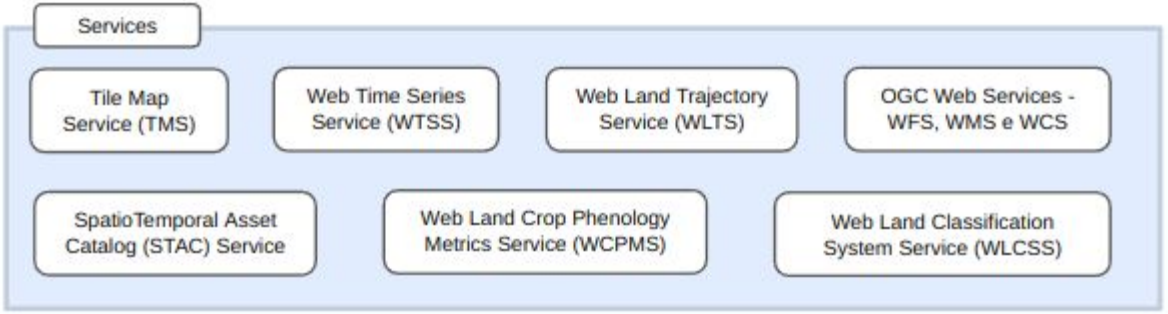
Dados e metadados



BRAZIL
DATA CUBE

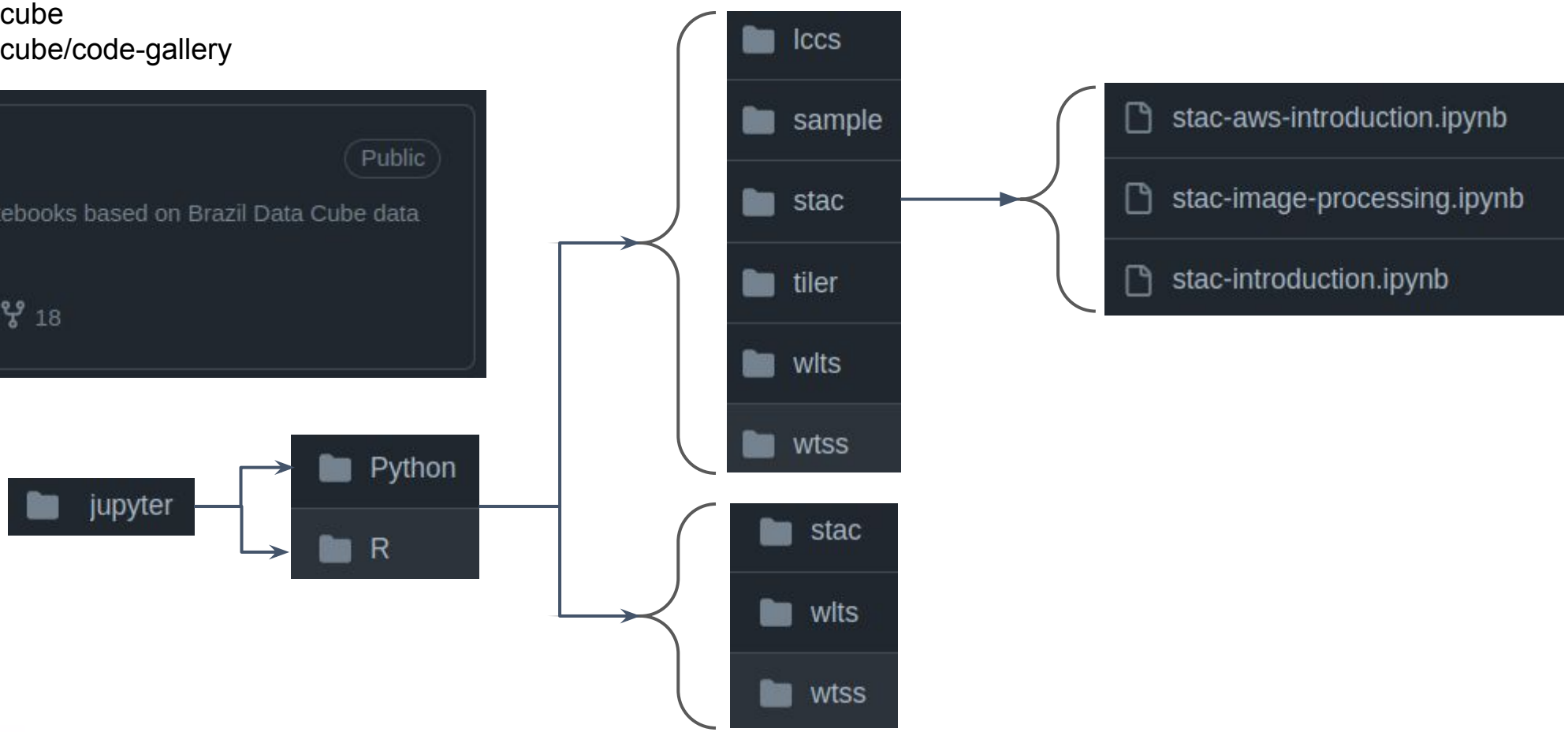
Open Data and Software Products

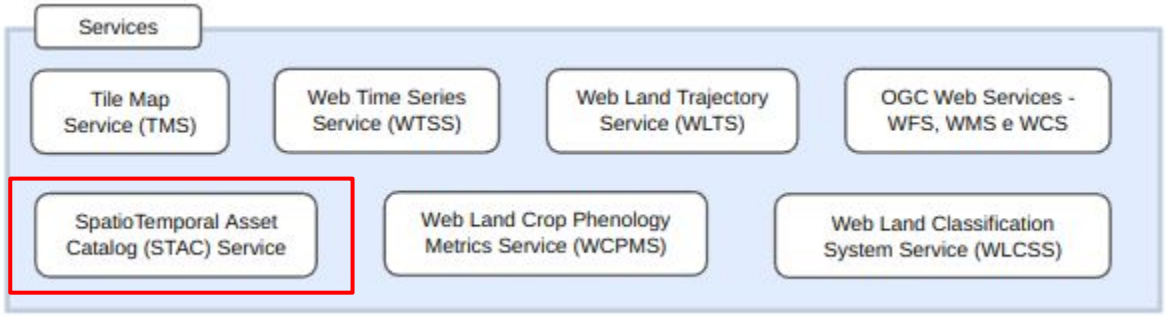




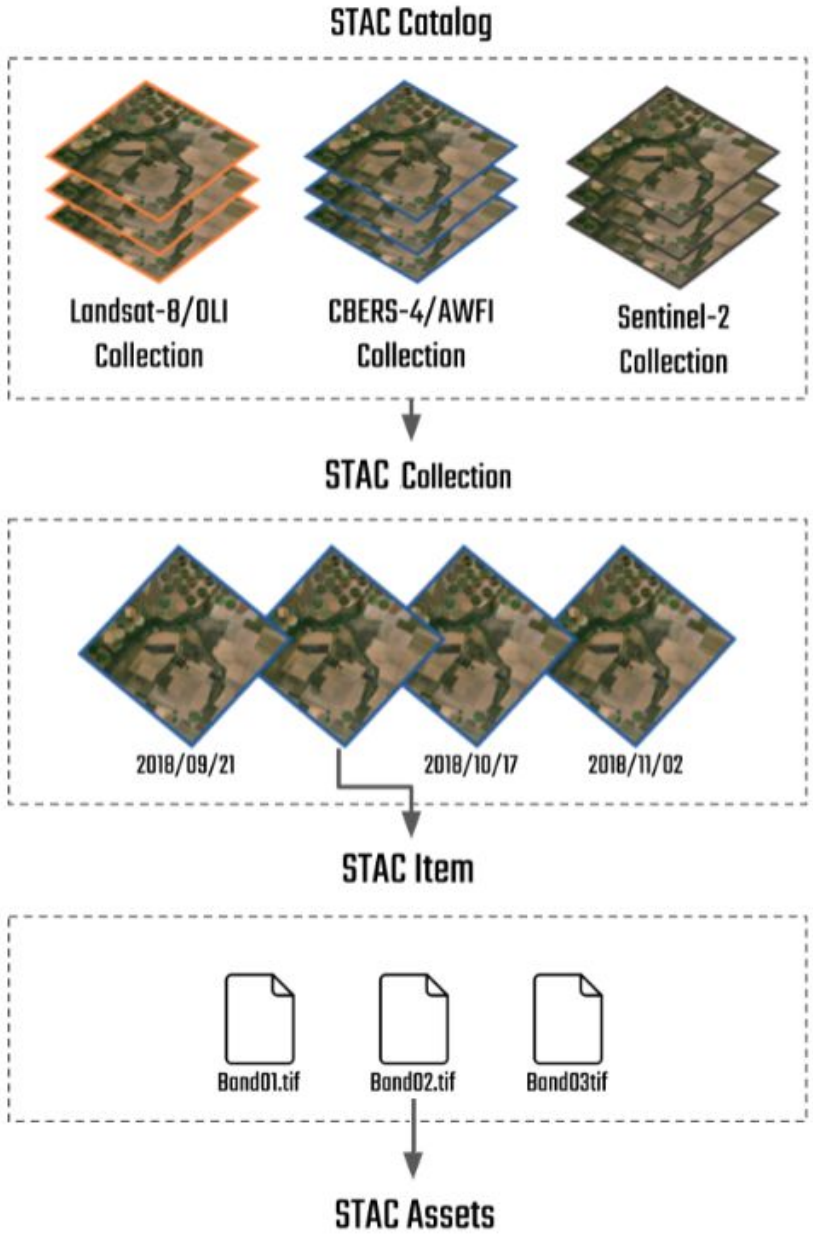
GitHub

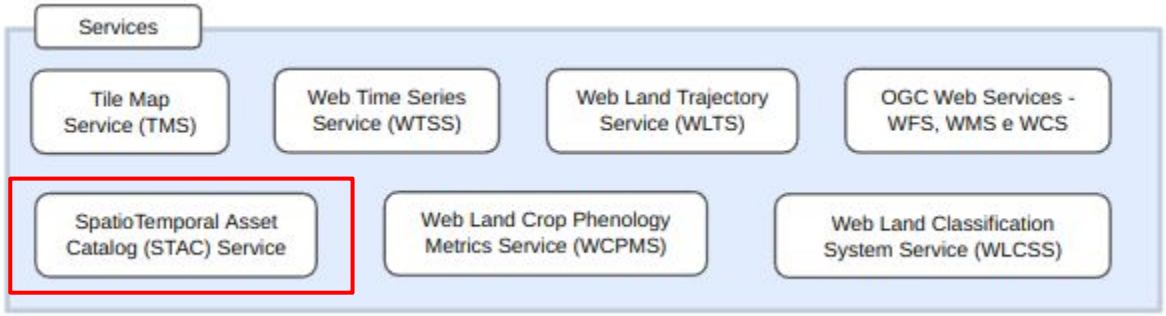
https://github.com/brazil-data-cube
https://github.com/brazil-data-cube/code-gallery





STAC
SpatioTemporal
Asset Catalog



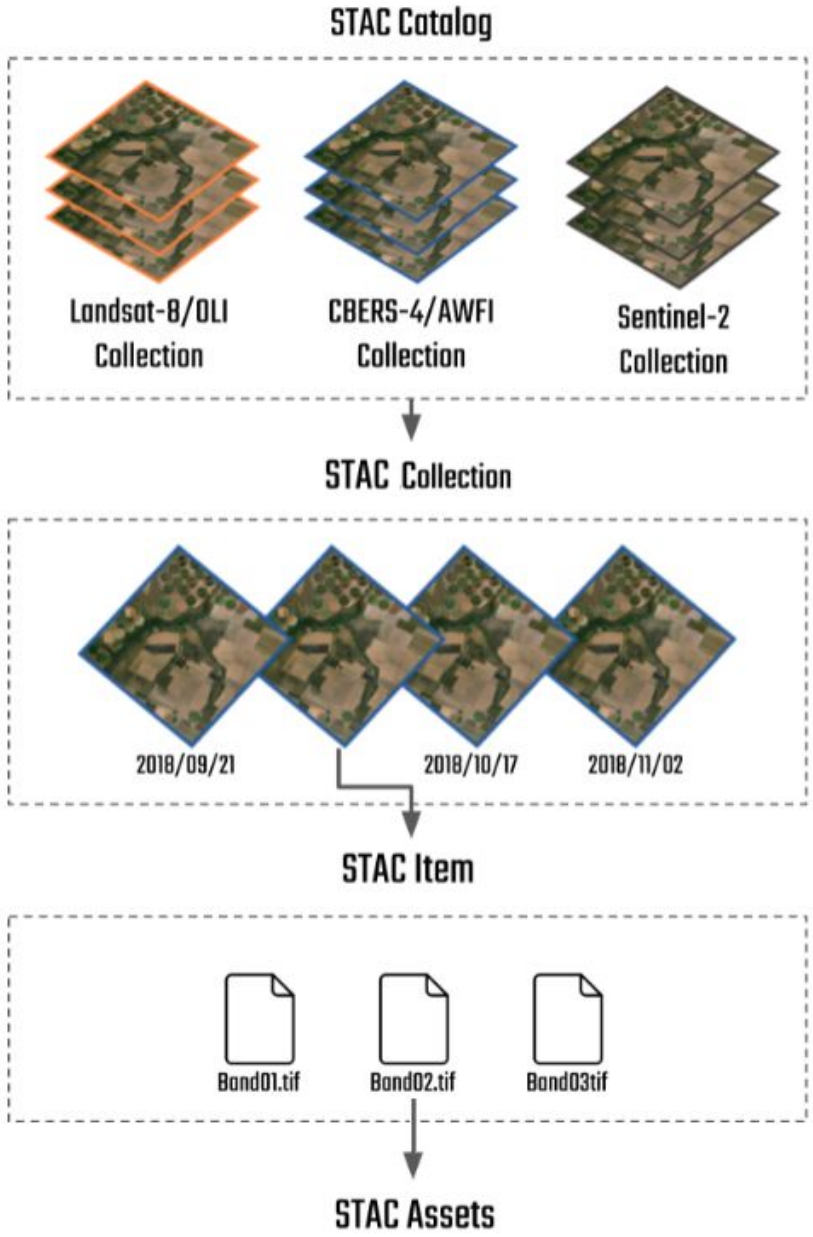


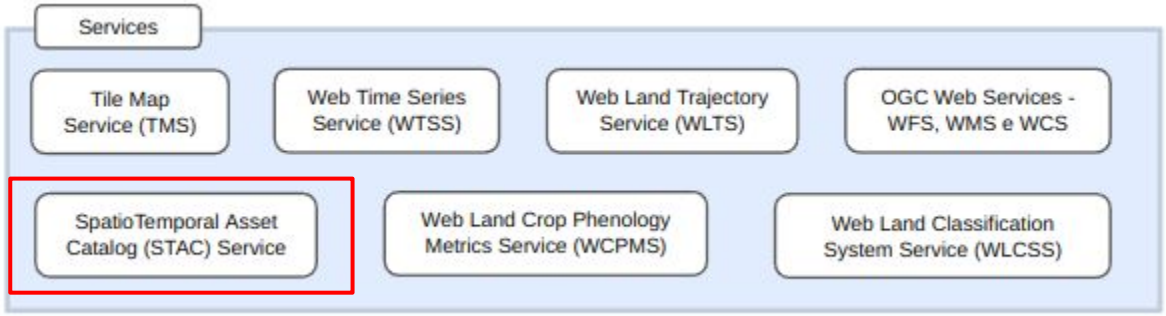
STAC
SpatioTemporal
Asset Catalog

INPE **STAC**:
https://data.inpe.br/bdc/stac/v1/

https://data.inpe.br/bdc/stac/v1/collections/S2_L2A-1/items?bbox=-45.9700,-23.2740,-45.8700,-23.0740&datetime=2024-01-01/2024-01-31&limit=20

INPE **STAC Browser**:
https://data.inpe.br/stac/browser/?.language=en





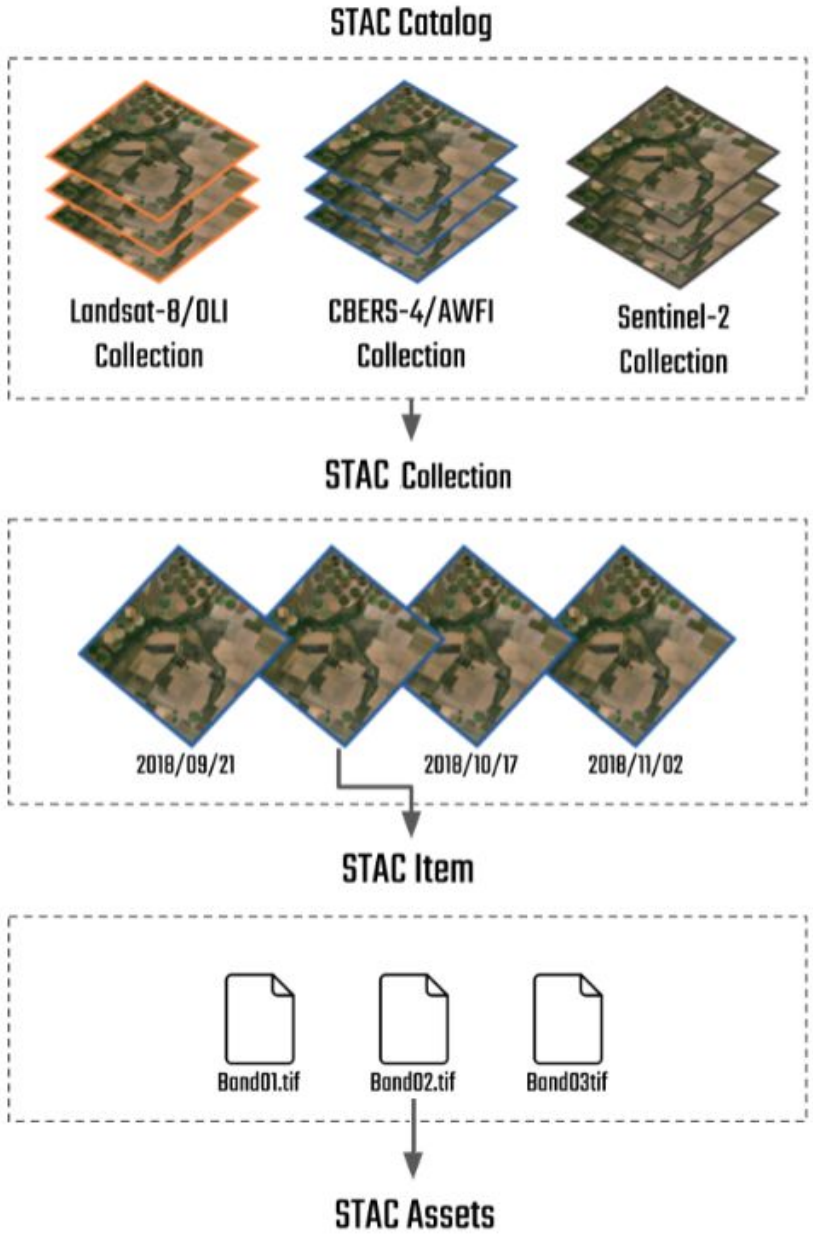
STAC
SpatioTemporal
Asset Catalog

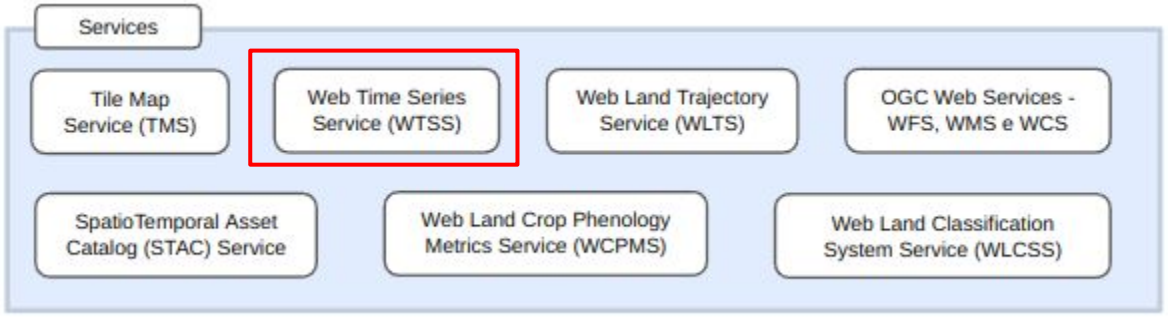
```
item_search = service.search(bbox=(-46.62597656250001,-13.19716452328198,
                                   -45.03570556640626,-12.297068292853805),
                            datetime='2018-08-01/2019-07-31',
                            collections=['CB4-16D-2'])

item_search
```

```
assets = item.assets
```

```
import rasterio
```

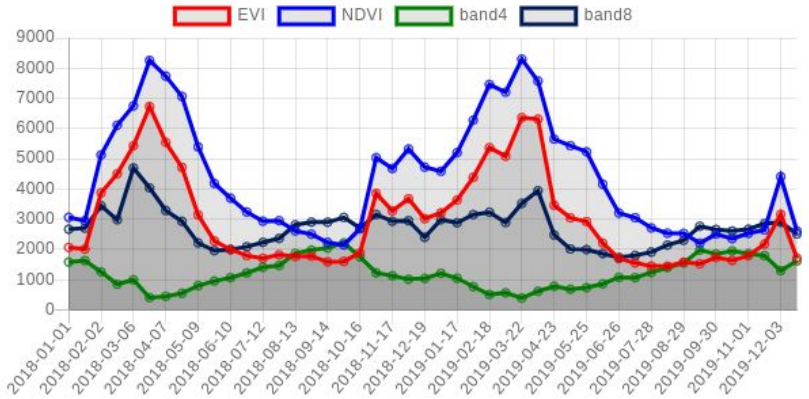
```
with rasterio.open(assets['BAND16'].href) as nir_ds:
    nir = nir_ds.read(1)
```





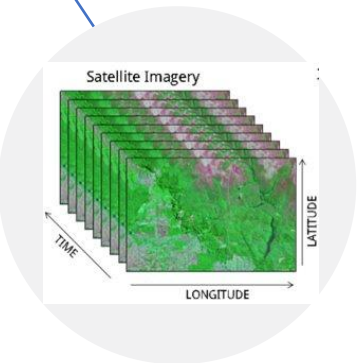
Web Time Series Service (WTSS)

Image time series

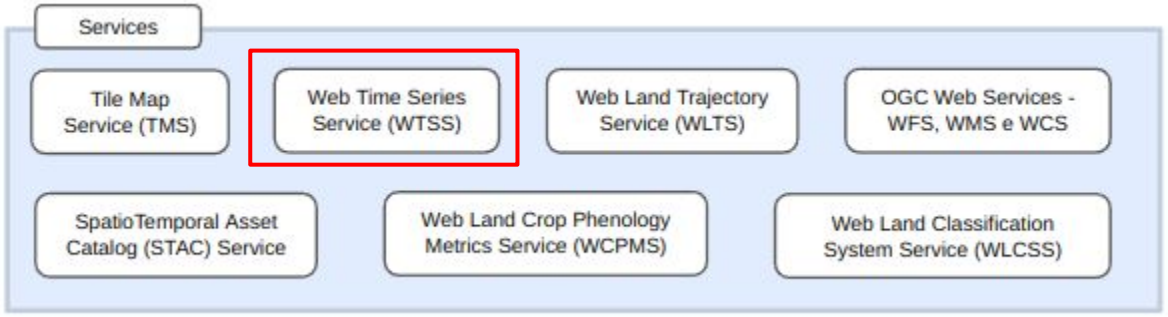


Clientes

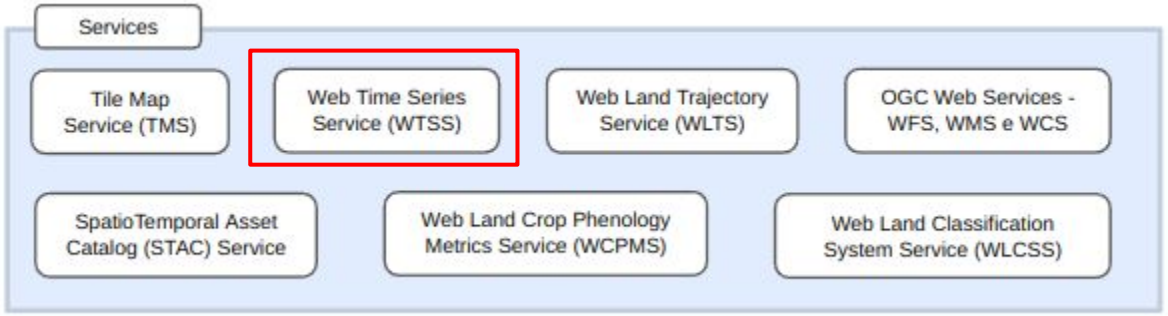
Metadata



Data cubes



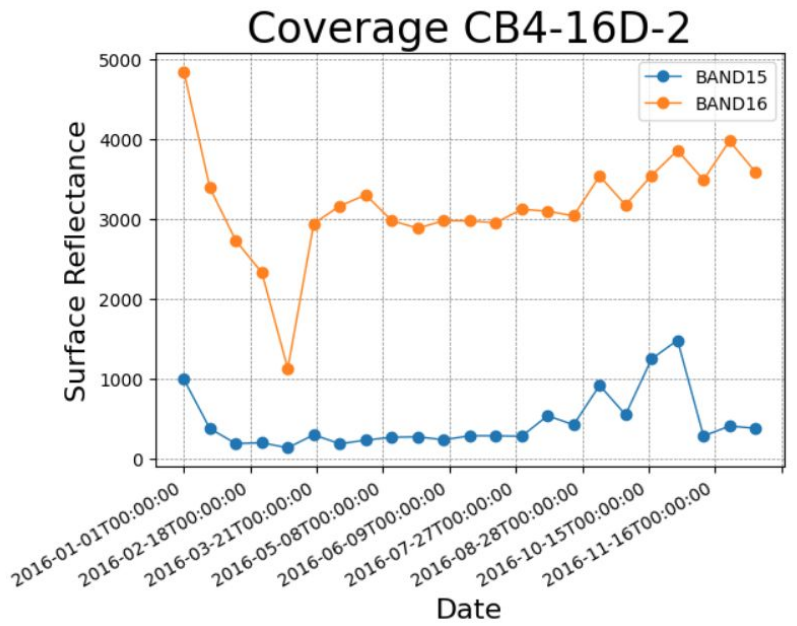
Web Time Series Service (WTSS)



Web Time Series Service (WTSS)

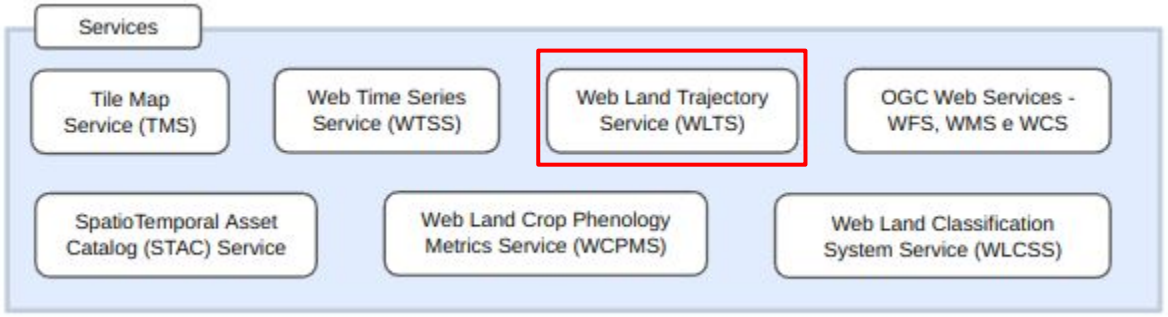
```
ts = coverage.ts(attributes=('BAND15', 'BAND16'),
                 latitude=-12.0, longitude=-54.0,
                 start_date='2016-01-01', end_date='2016-12-31')
```

```
ts.plot()
```




```
[15]: ts.BAND15

[15… [991.0,
      375.0,
      187.0,
      197.0,
      134.0,
      297.0,
      184.0,
      230.0,
      266.0,
      272.0,
      234.0,
      285.0,
      284.0,
      278.0,
      536.0,
      422.0,
      916.0,
      548.0,
      1247.0,
      1482.0,
      282.0,
      406.0,
      379.0]
```

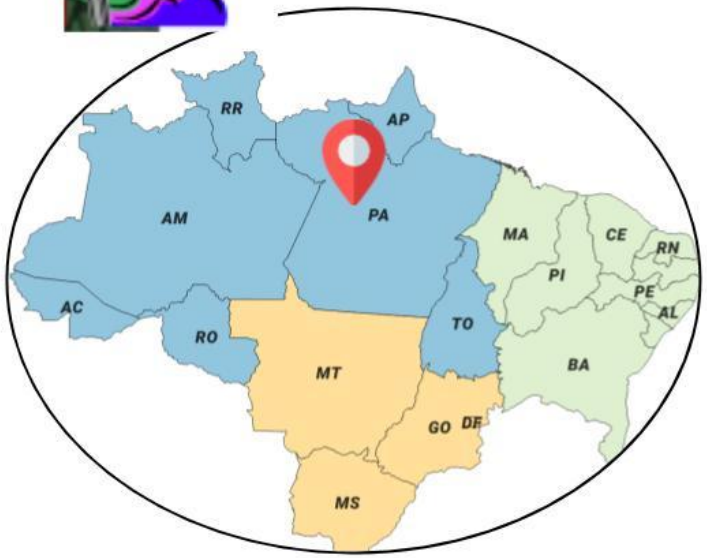
Web Land Trajectory Service (WLTS)



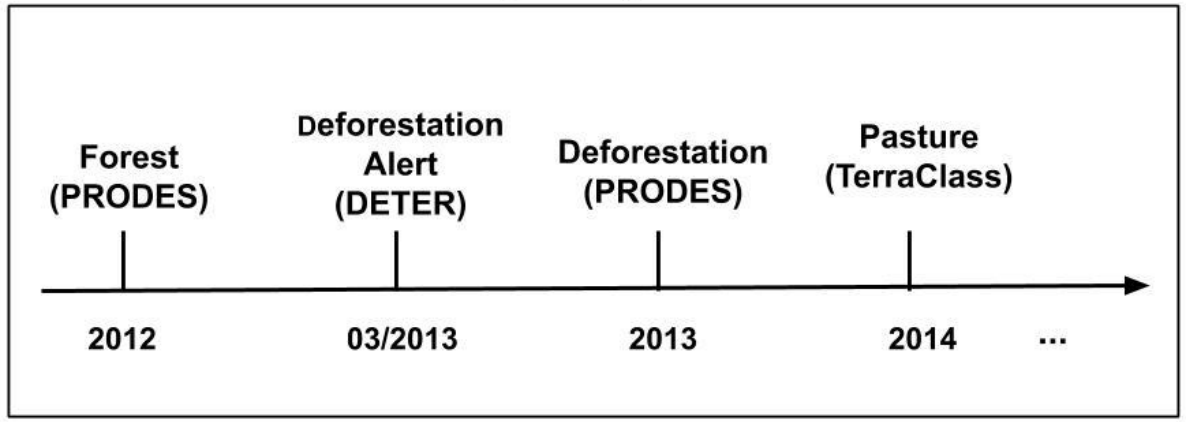
WLTS

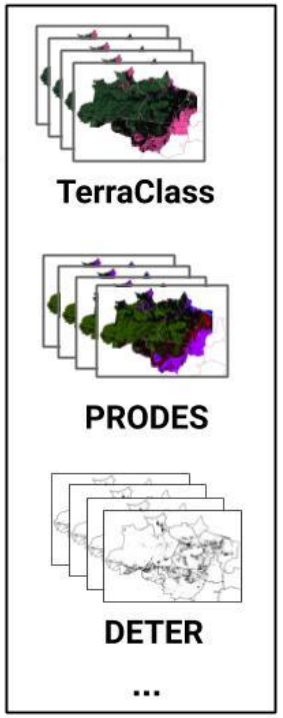
What is the trajectory of land use and cover at this location in PA?

Web Land Trajectory Service

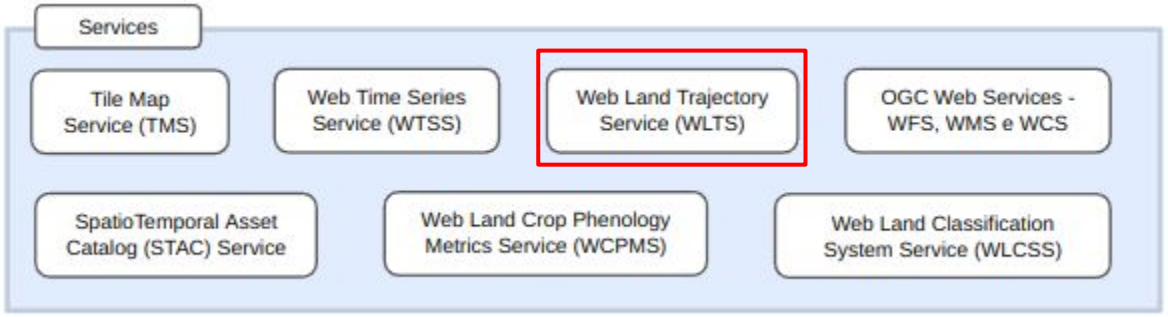


Land use and cover trajectory at this location in PA



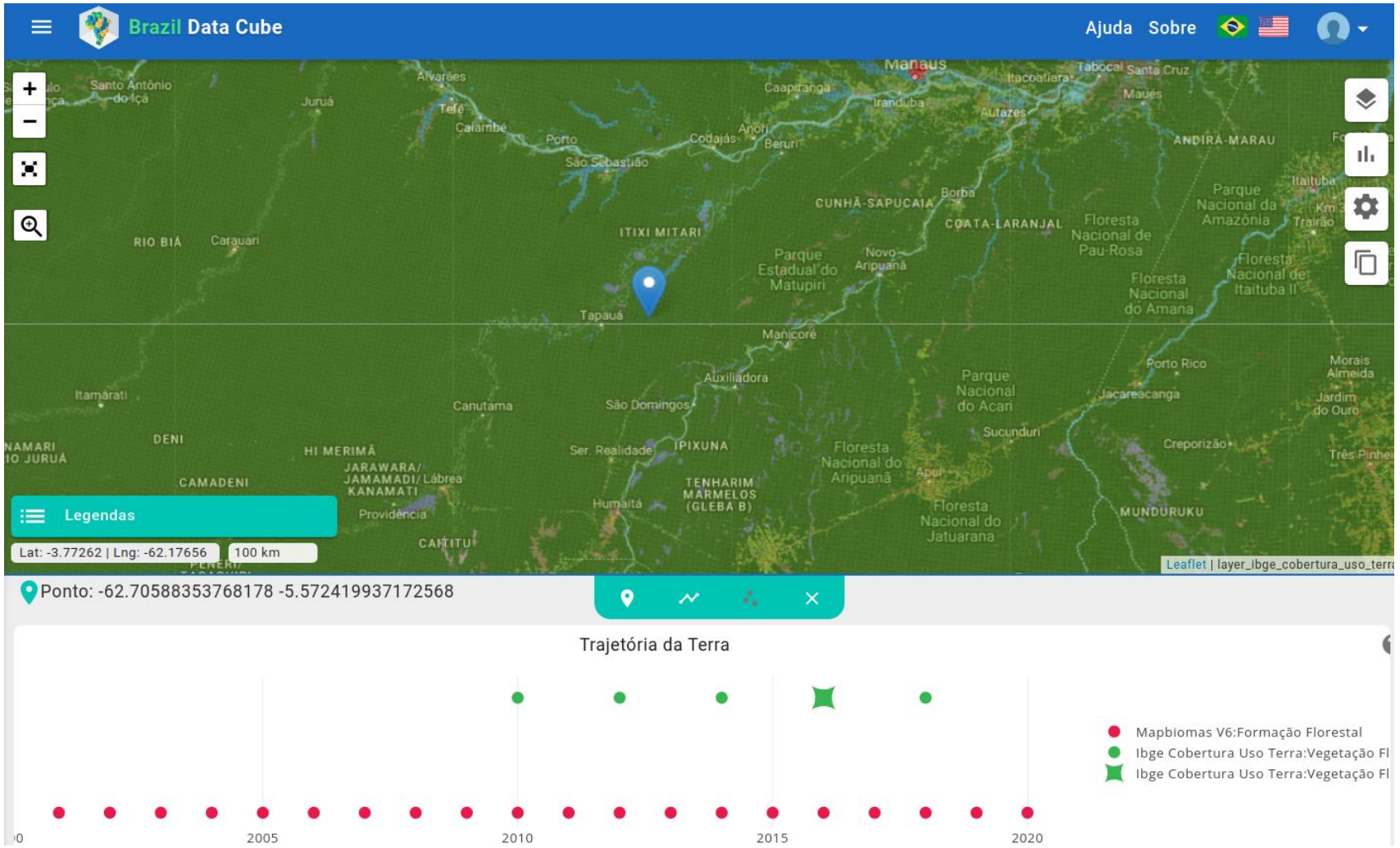


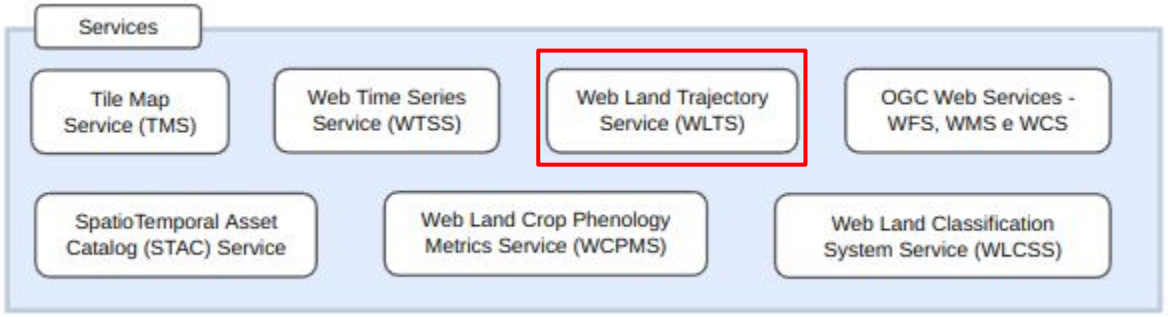
Land use and cover data sets



Web Land Trajectory Service (WLTS)

WLTS





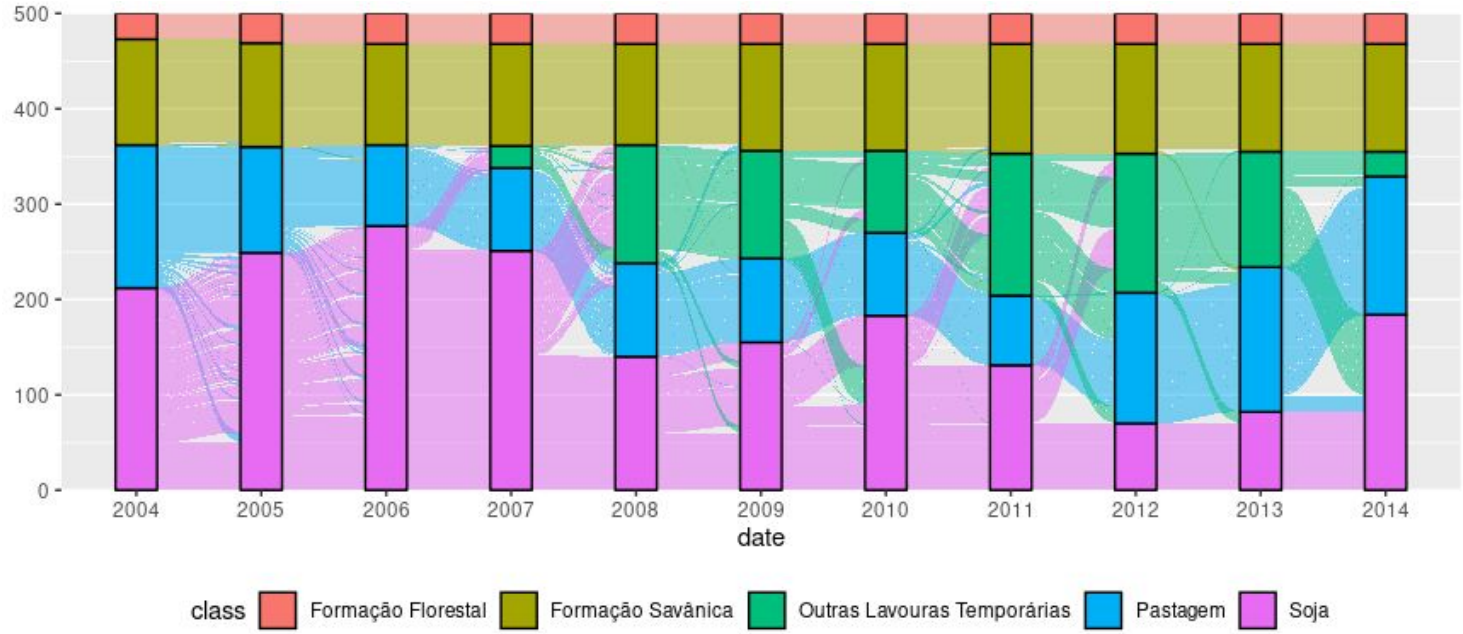
Web Land Trajectory Service (WLTS)

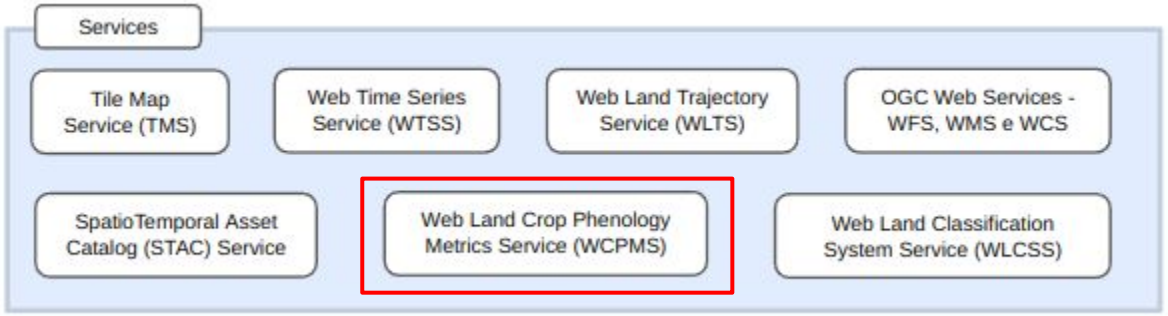
WLTS

```
tj_multiples_collections = service.tj(latitude=-12.0, longitude=-54.0, collections='mapbiomas-v8,terraclass_amazonia-v3')
```

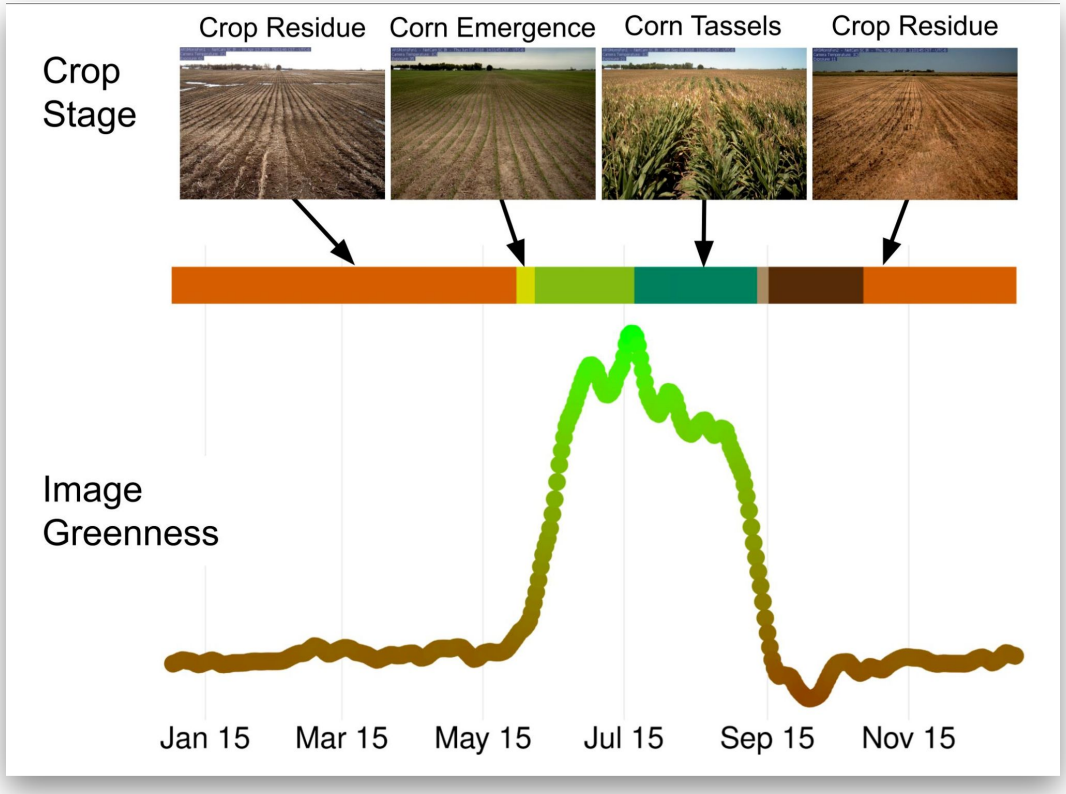
Trajectory

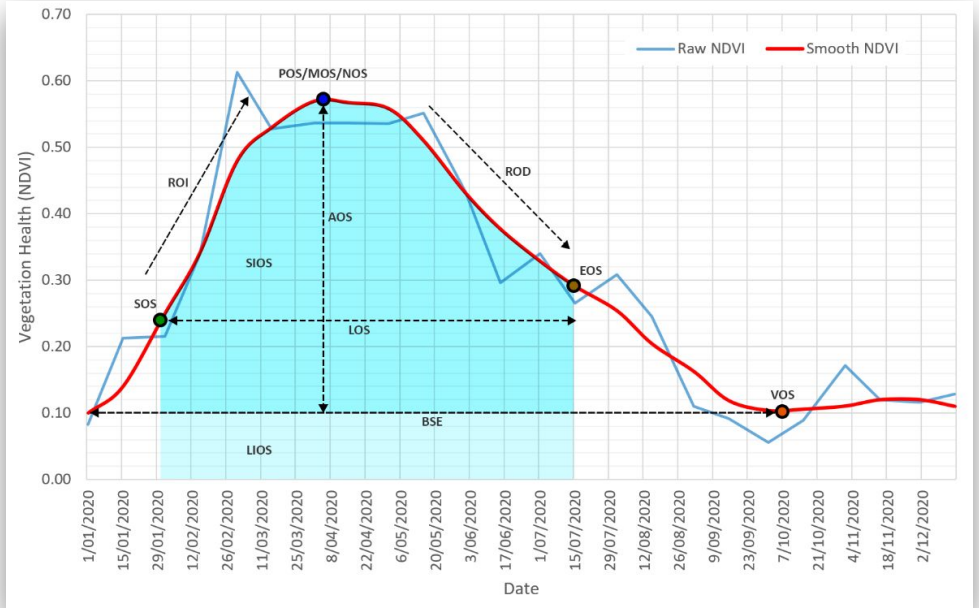
Class	Collection	Date
Formação Florestal	mapbiomas-v8	1985
Formação Florestal	mapbiomas-v8	1986
Formação Florestal	mapbiomas-v8	1987
Formação Florestal	mapbiomas-v8	2018
Formação Florestal	mapbiomas-v8	2019
Formação Florestal	mapbiomas-v8	2020
Vegetação Natural Florestal Primária	terraclass_amazonia-v3	2020
Formação Florestal	mapbiomas-v8	2021
Formação Florestal	mapbiomas-v8	2022

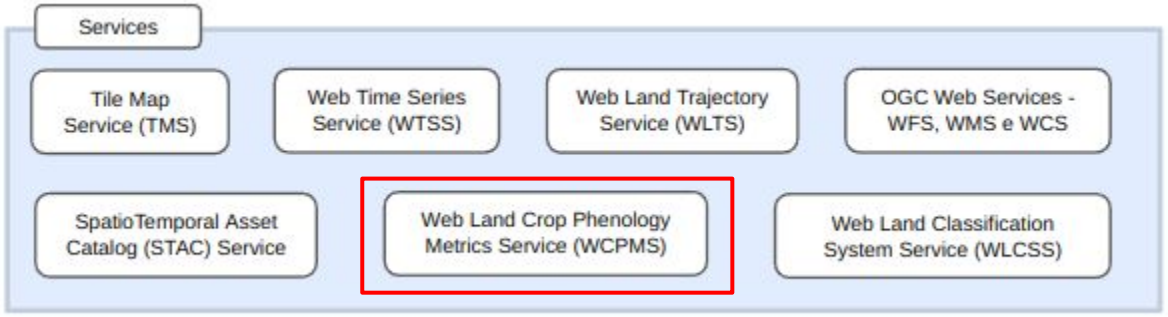




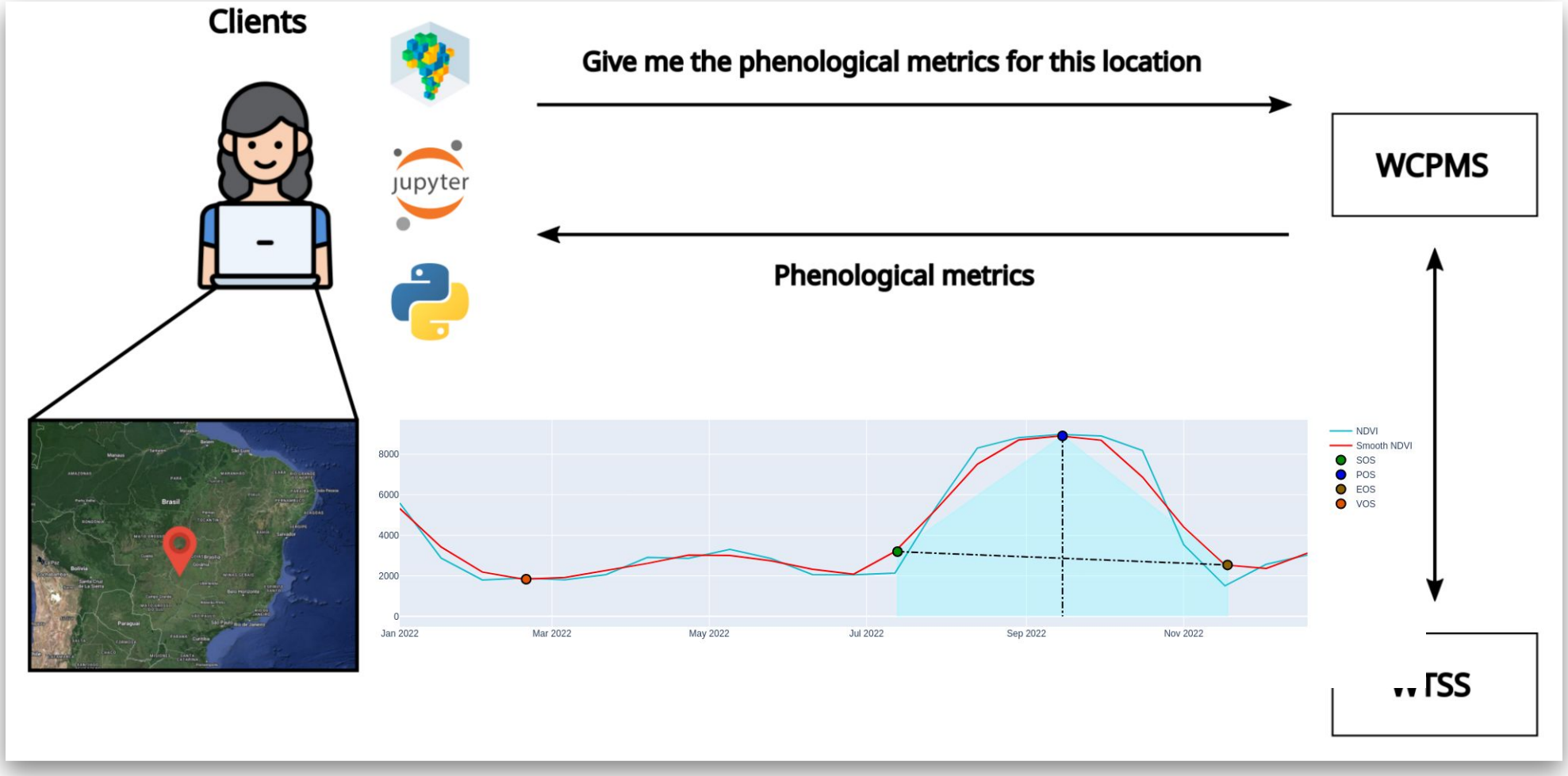
Web Crop Phenology Metrics Service (WCPMS)

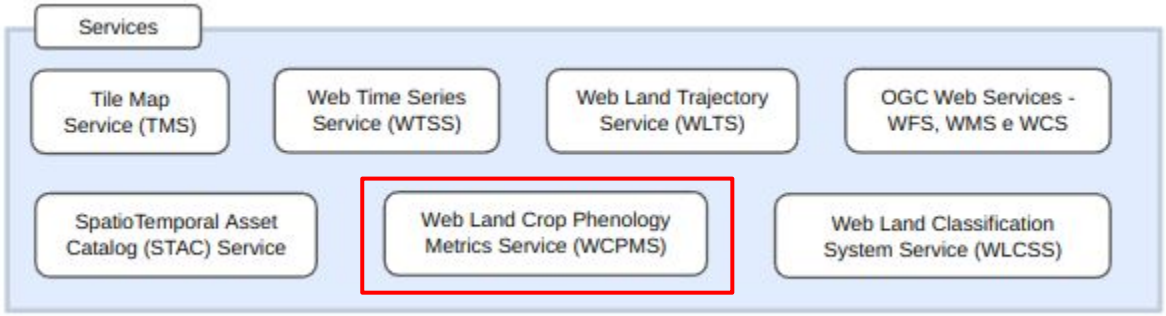






Web Crop Phenology Metrics Service (WCPMS)



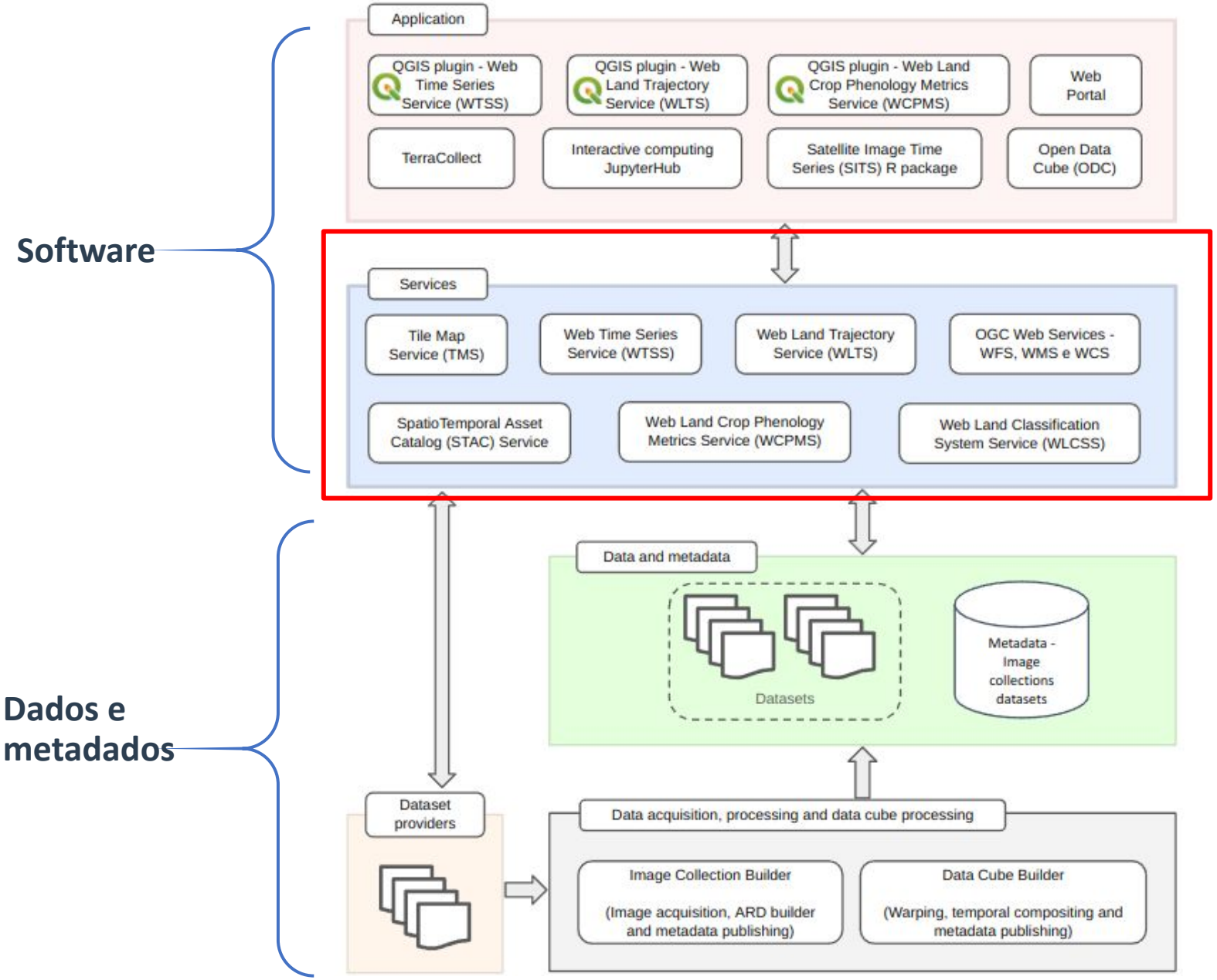


Web Crop Phenology Metrics Service (WCPMS)

```
from wcpms import *

# Defines URL of a instance of the WCPMS
wcpms_url = "http://data.inpe.br/bdc/wcpms"

# Defines a data cube query from Brazil Data
# Cube (BDC)
datacube = cube_query(
        collection="S2-16D-2",
        start_date="2022-01-01",
        end_date="2022-12-31",
        freq="16D",
        band="NDVI"
)

# Retrieving the phenological metrics
pm = get_phenometrics(
        url = wcpms_url,
        cube = datacube,
        latitude=-13.67705998895876,
        longitude=-52.47134616677471
)

# Visualizing the phenological metrics
print(pm)
```

BRAZIL
DATA CUBE

Open Data and Software Products

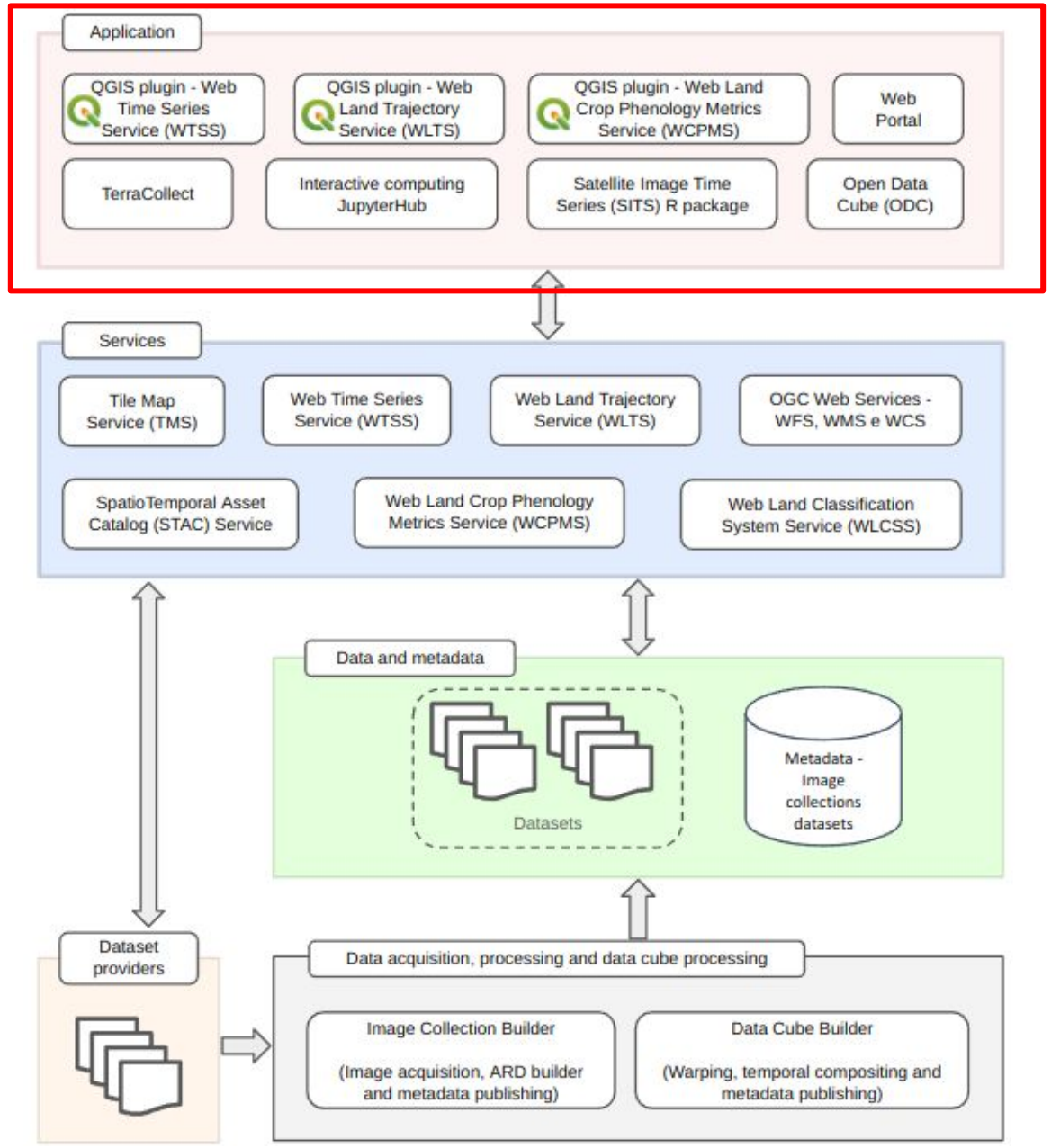


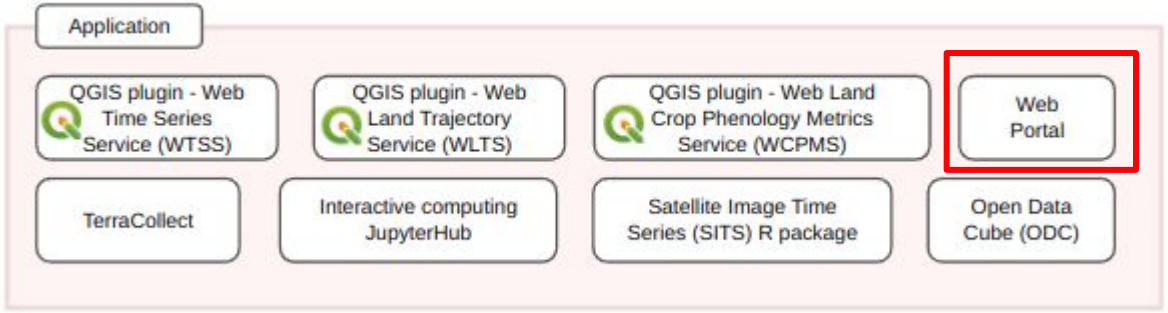
BRAZIL
DATA CUBE

Open Data and Software Products

Software

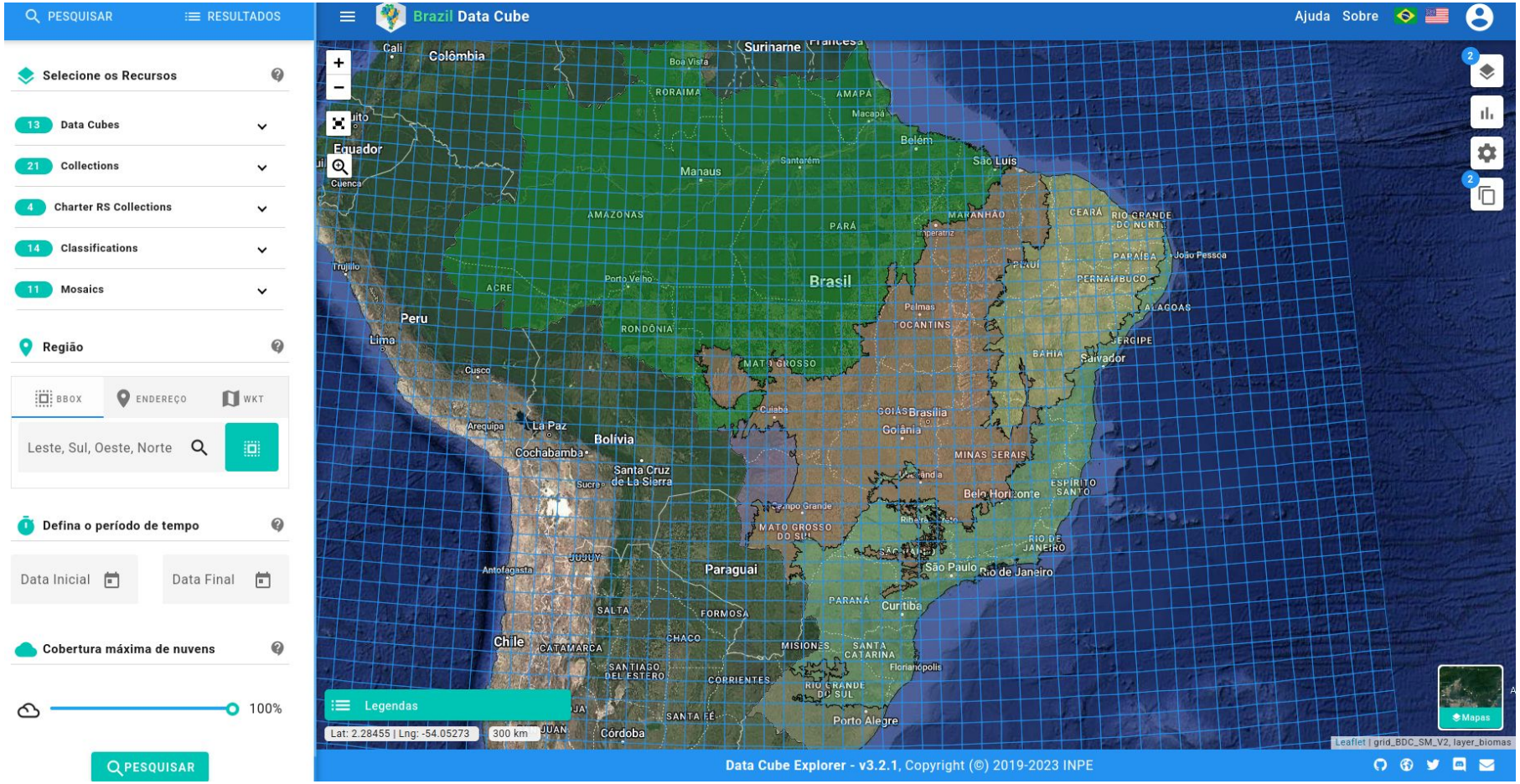
Dados e metadados





BDC Explorer

Web Portal



Source: [Ferreira et al, 2020]

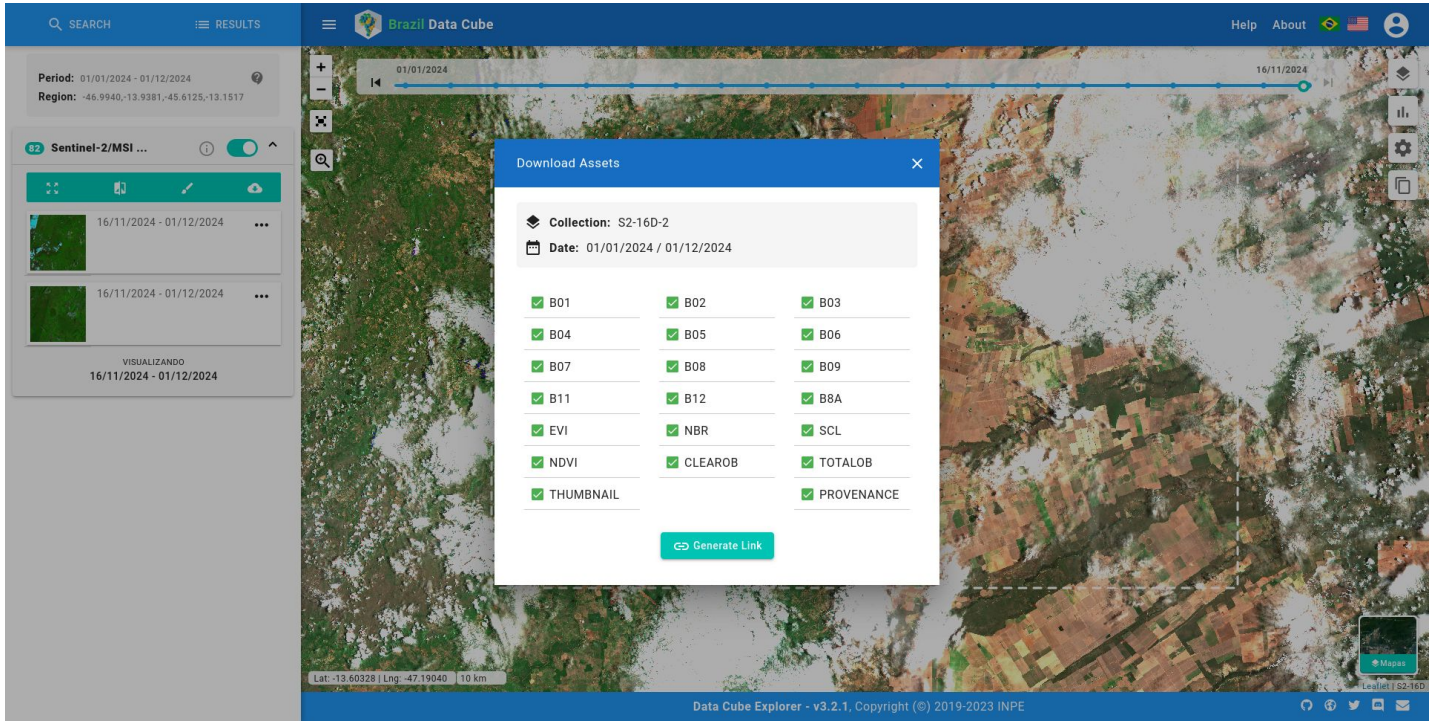
Data Cube Explorer

Data Cube Explorer is a web portal for **visualizing** data cubes, image collections and classifications.

https://data.inpe.br/bdc/explorer/

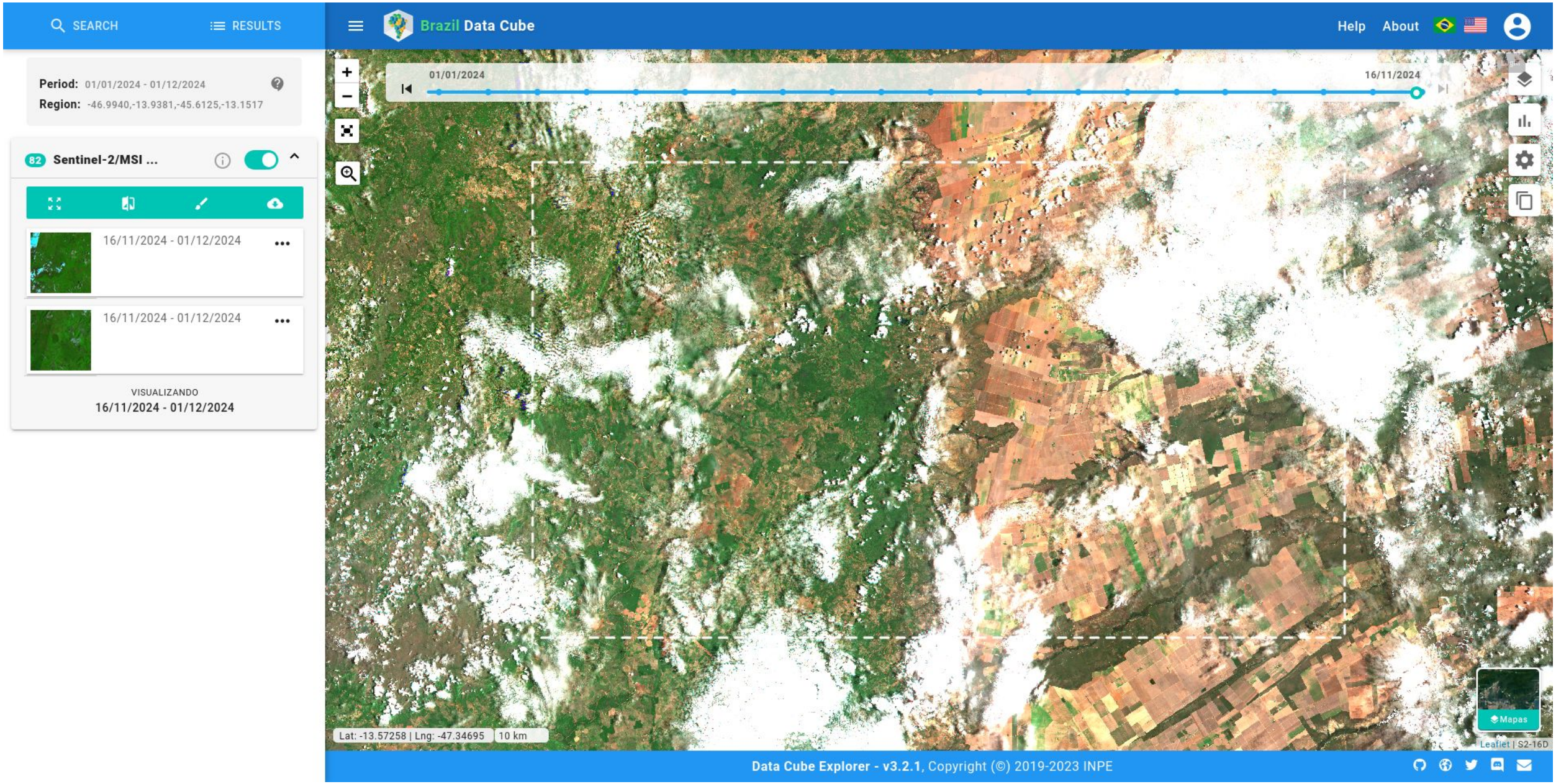
Data Cube Explorer

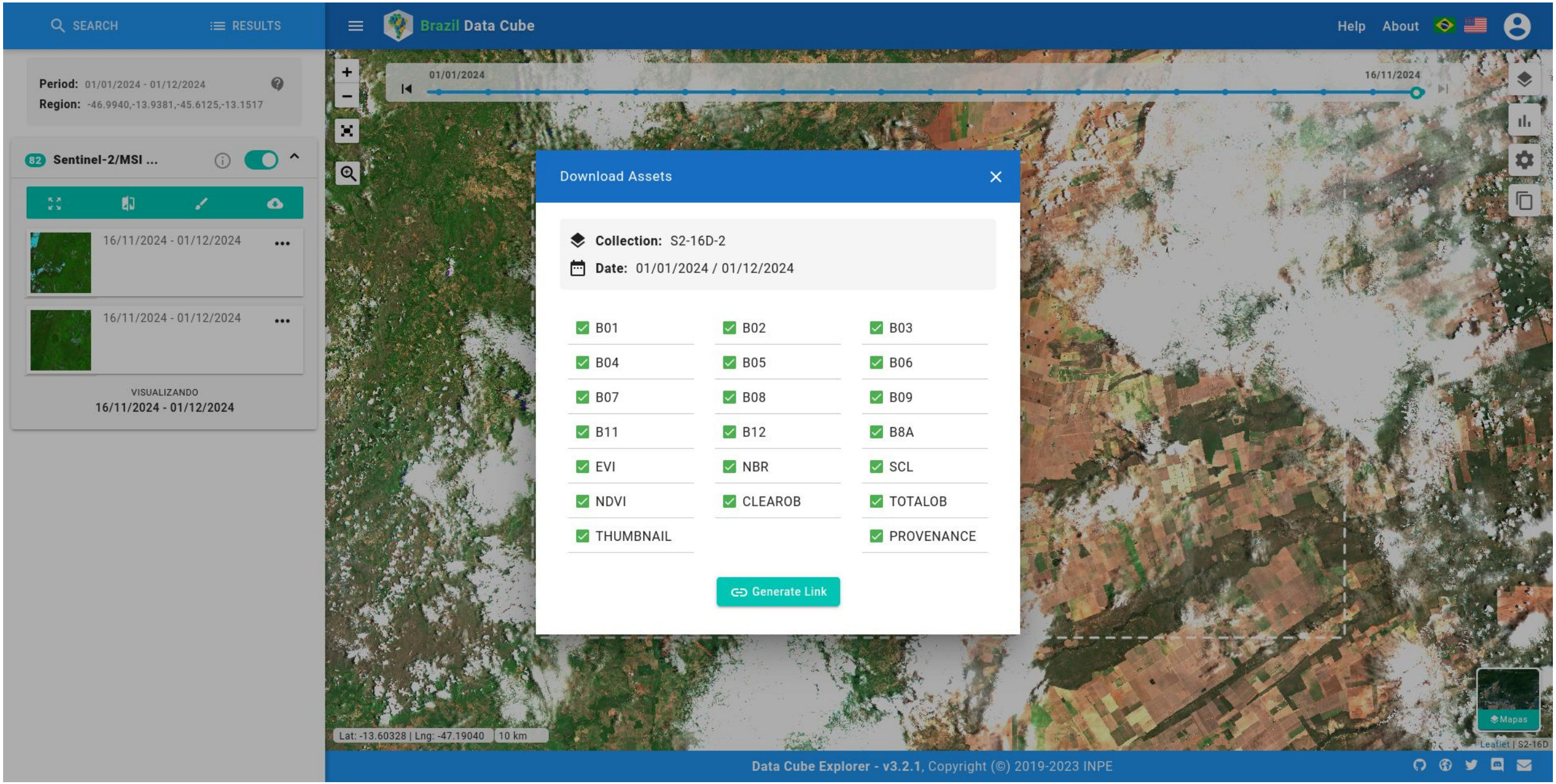
- DC Explorer has a set of features for **viewing** and **downloading** image collections, some of which are:
  - Spatio-temporal search of data cubes, image collections and classifications;
  - Temporal visualization of images, with timeline;
  - Visualization of time series and Earth's trajectory;
  - Editing the RGB composition of images;



https://data.inpe.br/bdc/explorer/


SEARCH
RESULTS
Brazil Data Cube
Help
About
Select Resources
9 Data Cubes
13 Collections
4 Charter RS Collections
11 Classifications
11 Mosaics
Region
BBOX
ADDRESS
WKT
West, South, East, North
Select the Period
Start Date
Last Date
Max. cloud coverage
100%
SEARCH
Lat: -26.19488 | Lng: -79.18945
300 km
Maps
Leaflet
Data Cube Explorer - v3.2.1, Copyright (©) 2019-2023 INPE


SEARCH
RESULTS
Brazil Data Cube
Help
About
Period: 01/01/2024 - 01/12/2024
Region: -46.9940,-13.9381,-45.6125,-13.1517
82 Sentinel-2/MSI ...
16/11/2024 - 01/12/2024
16/11/2024 - 01/12/2024
VISUALIZANDO
16/11/2024 - 01/12/2024
01/01/2024
16/11/2024
Lat: -13.57258 | Lng: -47.34695
10 km
Mapas
Leaflet | S2-16D
Data Cube Explorer - v3.2.1, Copyright (©) 2019-2023 INPE


SEARCH
RESULTS
Brazil Data Cube
Help
About
Period: 01/01/2024 - 01/12/2024
Region: -46.9940,-13.9381,-45.6125,-13.1517
82 Sentinel-2/MSI ...
16/11/2024 - 01/12/2024
16/11/2024 - 01/12/2024
VISUALIZANDO
16/11/2024 - 01/12/2024
01/01/2024
16/11/2024
Download Assets
Collection: S2-16D-2
Date: 01/01/2024 / 01/12/2024
B01
B02
B03
B04
B05
B06
B07
B08
B09
B11
B12
B8A
EVI
NBR
SCL
NDVI
CLEAROB
TOTALOB
THUMBNAIL
PROVENANCE
Generate Link
Lat: -13.60328 | Lng: -47.19040
10 km
Mapas
Leaflet | S2-16D
Data Cube Explorer - v3.2.1, Copyright (©) 2019-2023 INPE

SEARCH RESULTS

Brazil Data Cube

Help About

Period: 01/01/2024 - 01/12/2024
Region: -61.0620,-4.5874,-55.2777,-1.9826

587 Sentinel-2/MSI ...

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

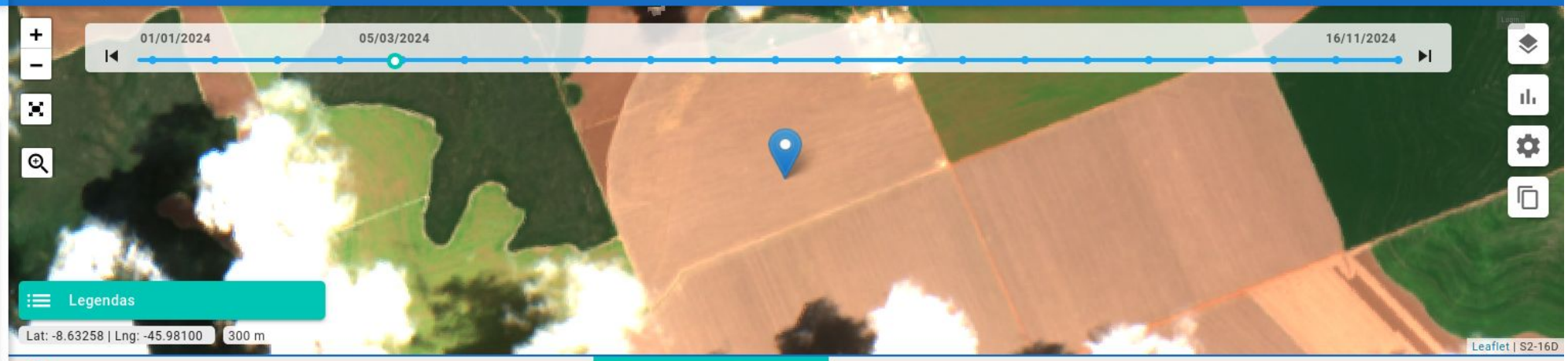
05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

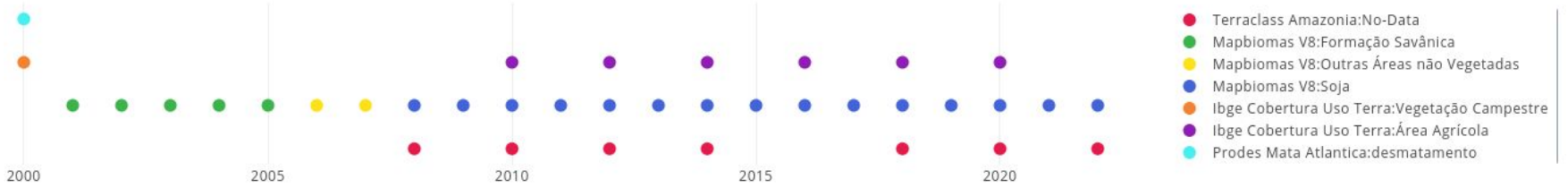
VISUALIZANDO
05/03/2024 - 20/03/2024

« 1 2 3 4 5 6 »

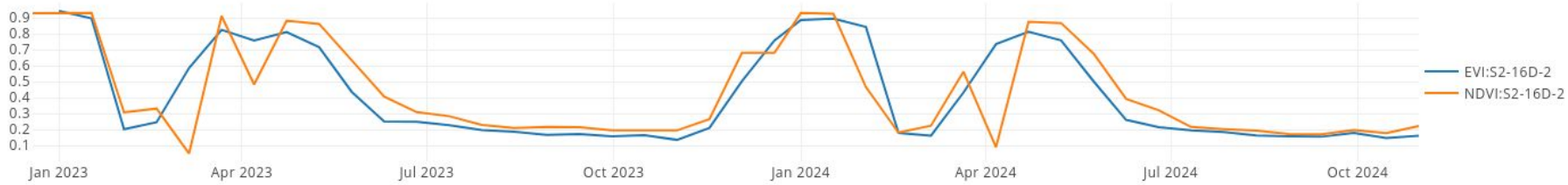


Ponto: -45.97031593322754 -8.625914727450066

Trajetória da Terra



Série Temporal



SEARCH RESULTS

Brazil Data Cube

Help About

Period: 01/01/2024 - 01/12/2024

Region: -61.0620,-4.5874,-55.2777,-1.9826

587 Sentinel-2/MSI ...

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

05/03/2024 - 20/03/2024

VISUALIZANDO

05/03/2024 - 20/03/2024

« 1 2 3 4 5 6 »

01/01/2024 05/03/2024 16/11/2024

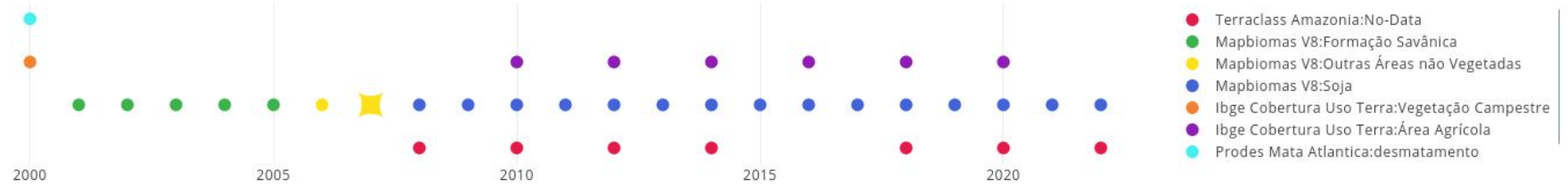
Legendas

Lat: -8.63169 | Lng: -45.95873 300 m

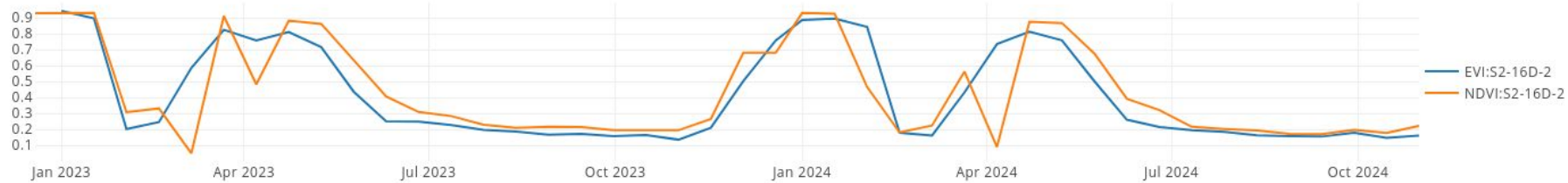
Leaflet | S2-16D, layer_mapbiomas-brasil-v8

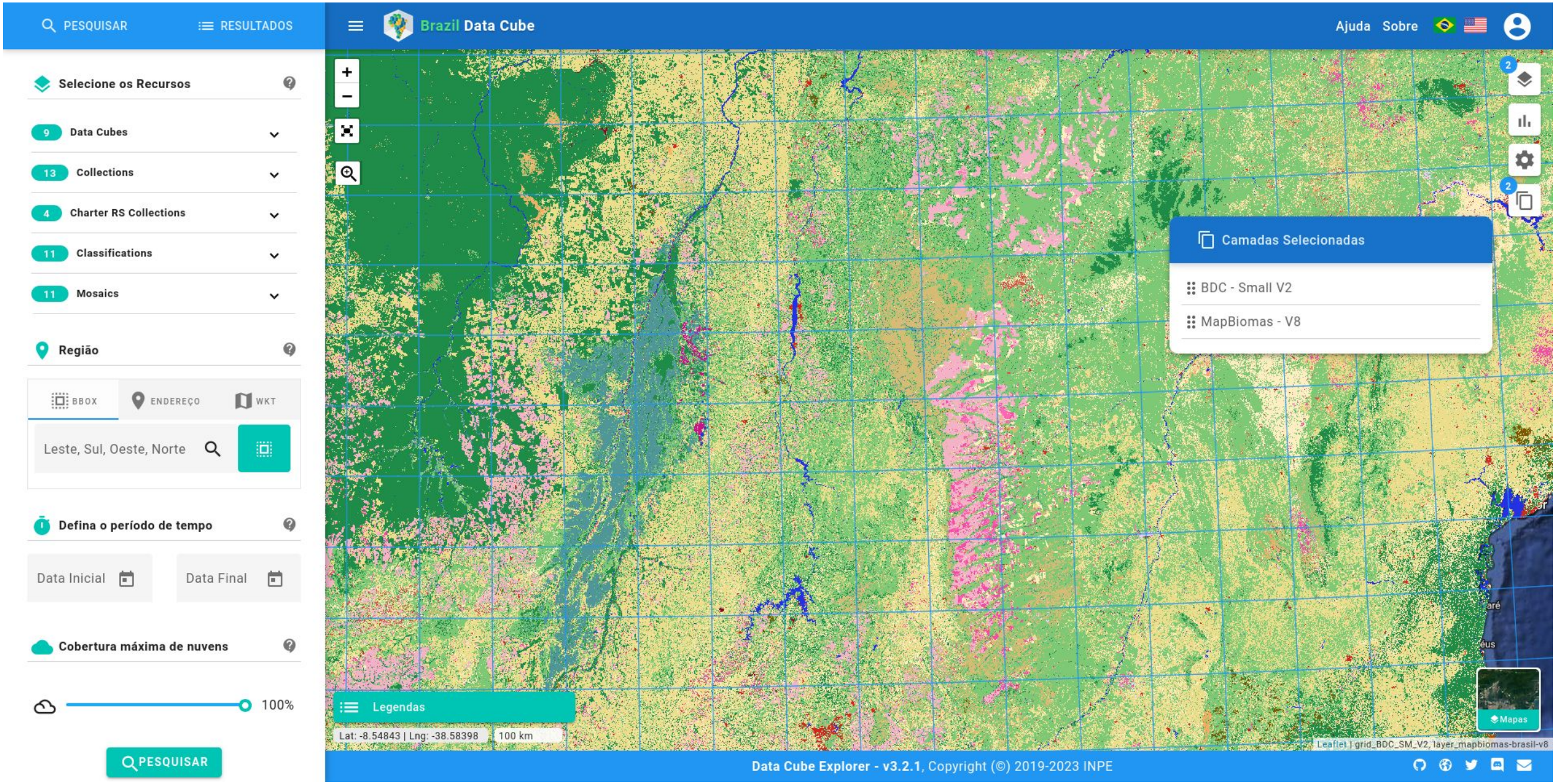
Ponto: -45.97031593322754 -8.625914727450066

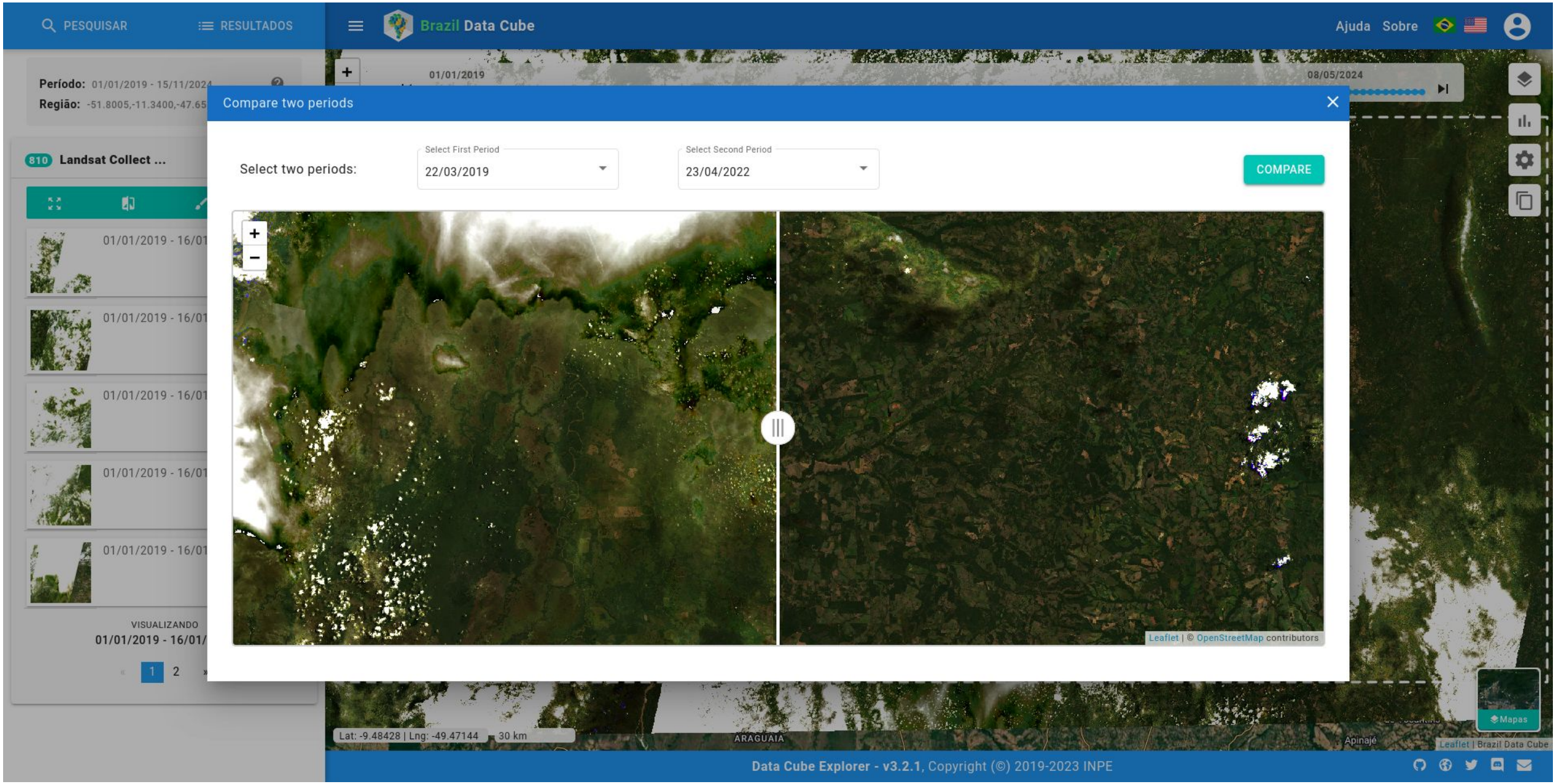
Trajetória da Terra

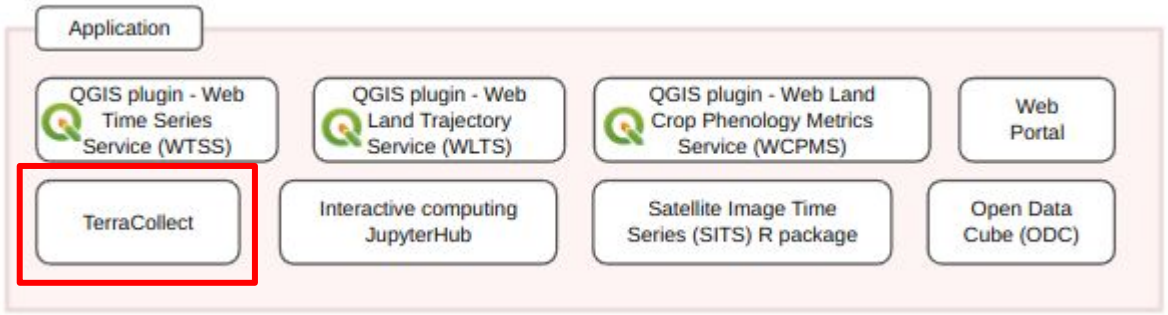


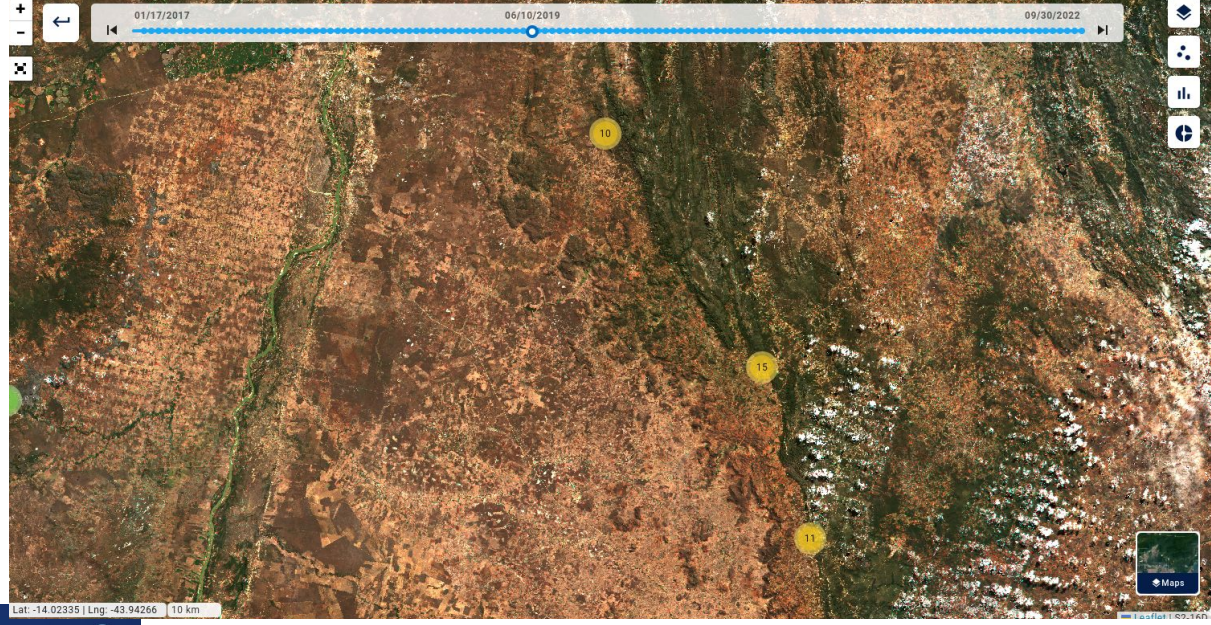
Série Temporal




PESQUISAR
RESULTADOS
Brazil Data Cube
Ajuda
Sobre
Selecione os Recursos
9 Data Cubes
13 Collections
4 Charter RS Collections
11 Classifications
11 Mosaics
Região
BBOX
ENDEREÇO
WKT
Leste, Sul, Oeste, Norte
Defina o período de tempo
Data Inicial
Data Final
Cobertura máxima de nuvens
100%
PESQUISAR
Camadas Selecionadas
BDC - Small V2
MapBiomas - V8
Legendas
Lat: -8.54843 | Lng: -38.58398
100 km
Mapas
Leaflet | grid_BDC_SM_V2, layer_mapbiomas-brasil-v8
Data Cube Explorer - v3.2.1, Copyright (©) 2019-2023 INPE


PESQUISAR
RESULTADOS
Brazil Data Cube
Ajuda
Sobre
Período: 01/01/2019 - 15/11/2024
Região: -51.8005,-11.3400,-47.65
810 Landsat Collect ...
01/01/2019 - 16/01
01/01/2019 - 16/01
01/01/2019 - 16/01
01/01/2019 - 16/01
01/01/2019 - 16/01
VISUALIZANDO
01/01/2019 - 16/01/
1
2
01/01/2019
08/05/2024
Compare two periods
Select two periods:
Select First Period
22/03/2019
Select Second Period
23/04/2022
COMPARE
Leaflet | © OpenStreetMap contributors
Mapas
Lat: -9.48428 | Lng: -49.47144
30 km
ARAGUAIA
Apinajé
Leaflet | Brazil Data Cube
Data Cube Explorer - v3.2.1, Copyright (©) 2019-2023 INPE



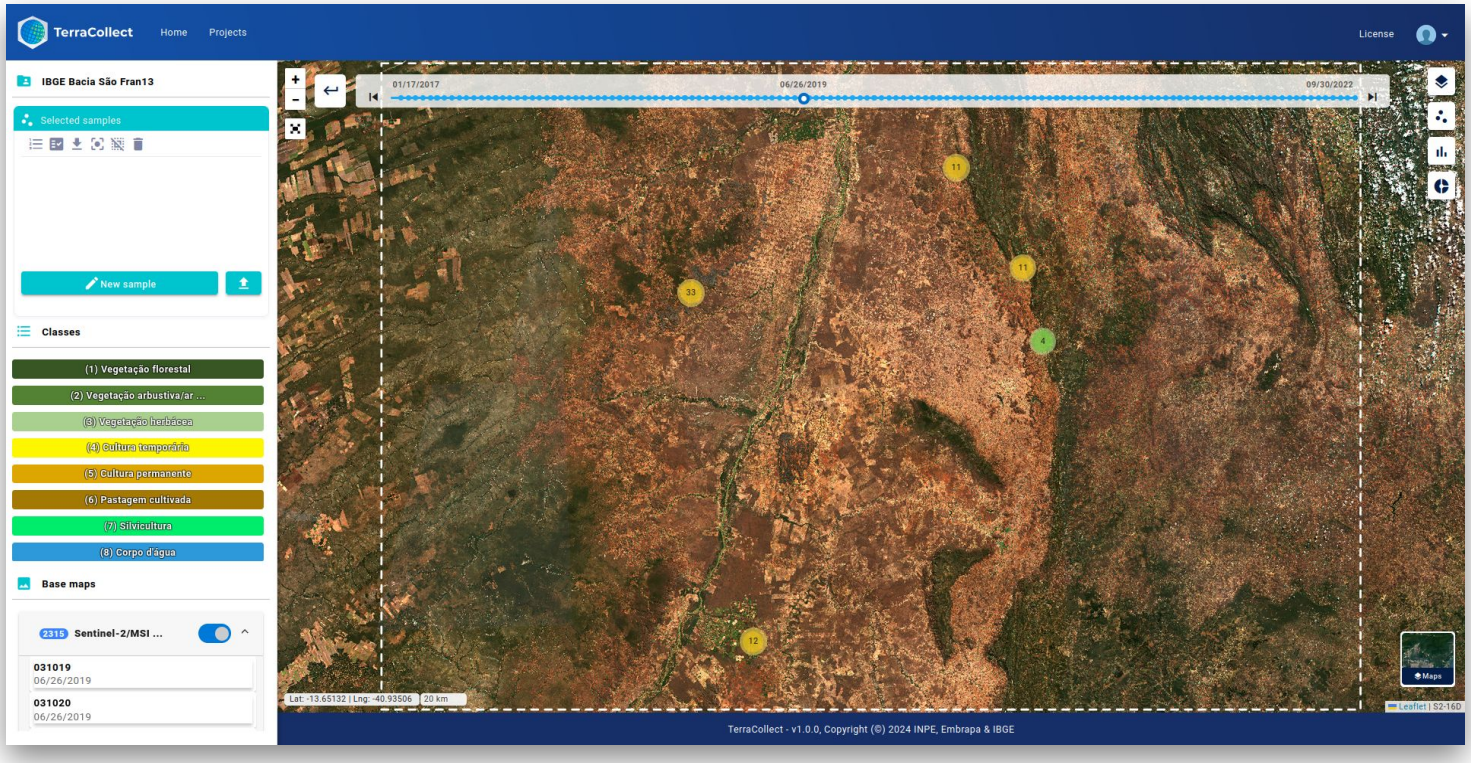


TerraCollect

web platform to collect and analyze land use and cover samples.

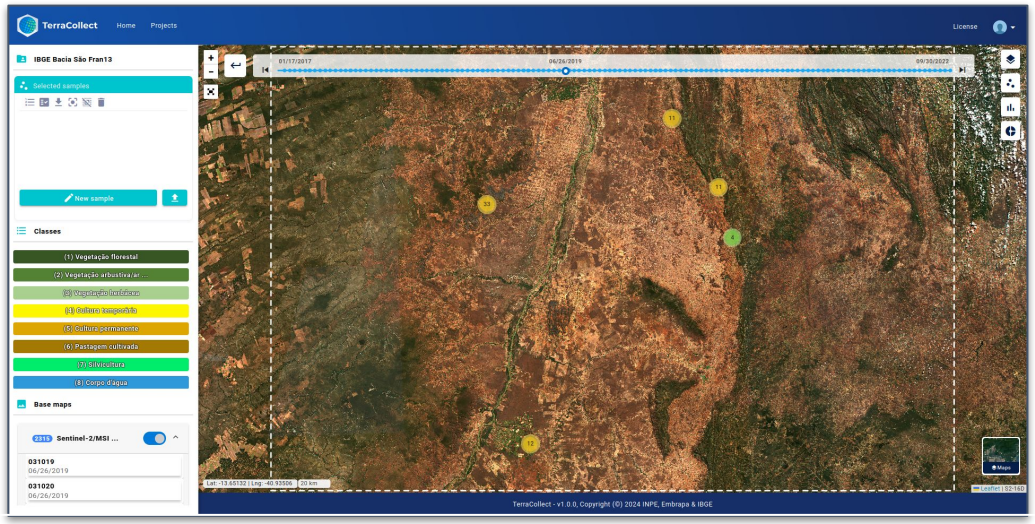
TerraCollect Overview

- TerraCollect is a web tool from Brazil Data Cube for **sample collection and analysis work**.
- It provides **high-resolution multi-temporal images** through image collections from Brazil Data Cube.
- One of the features of it the TerraCollect is the integration with the Brazil Data Cube **earth sample database, the Sample-DB**.

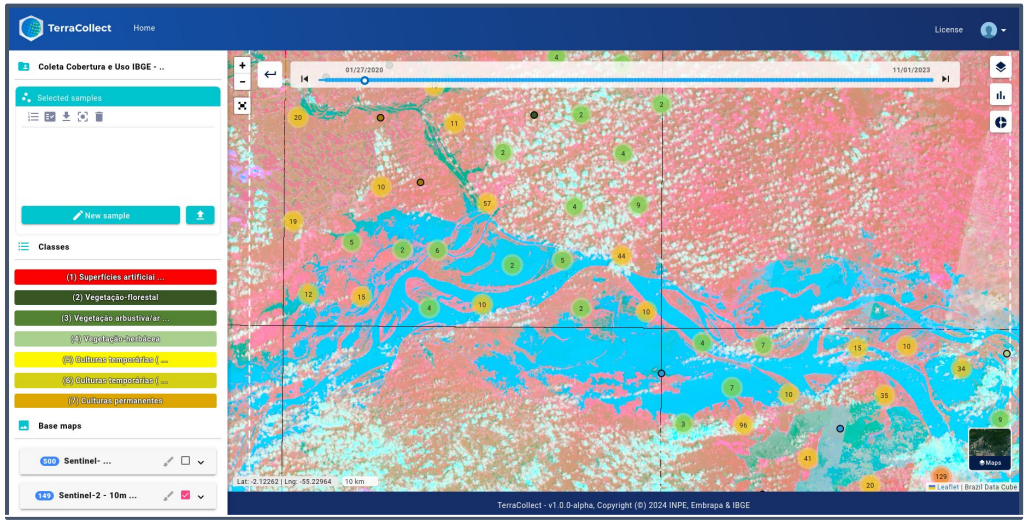


https://data.inpe.br/bdc/terracollect

TerraCollect integrated features

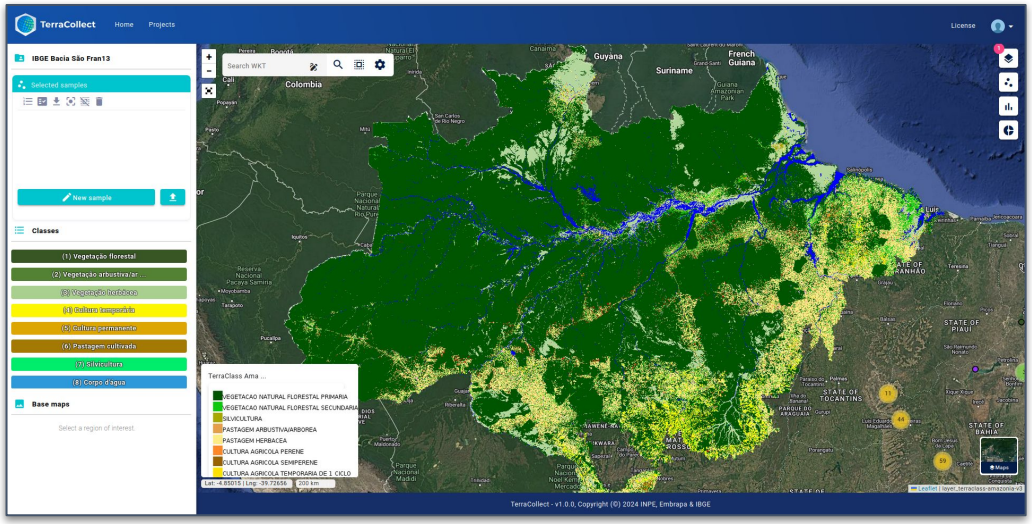


Viewing cubes and image collections, with timeline



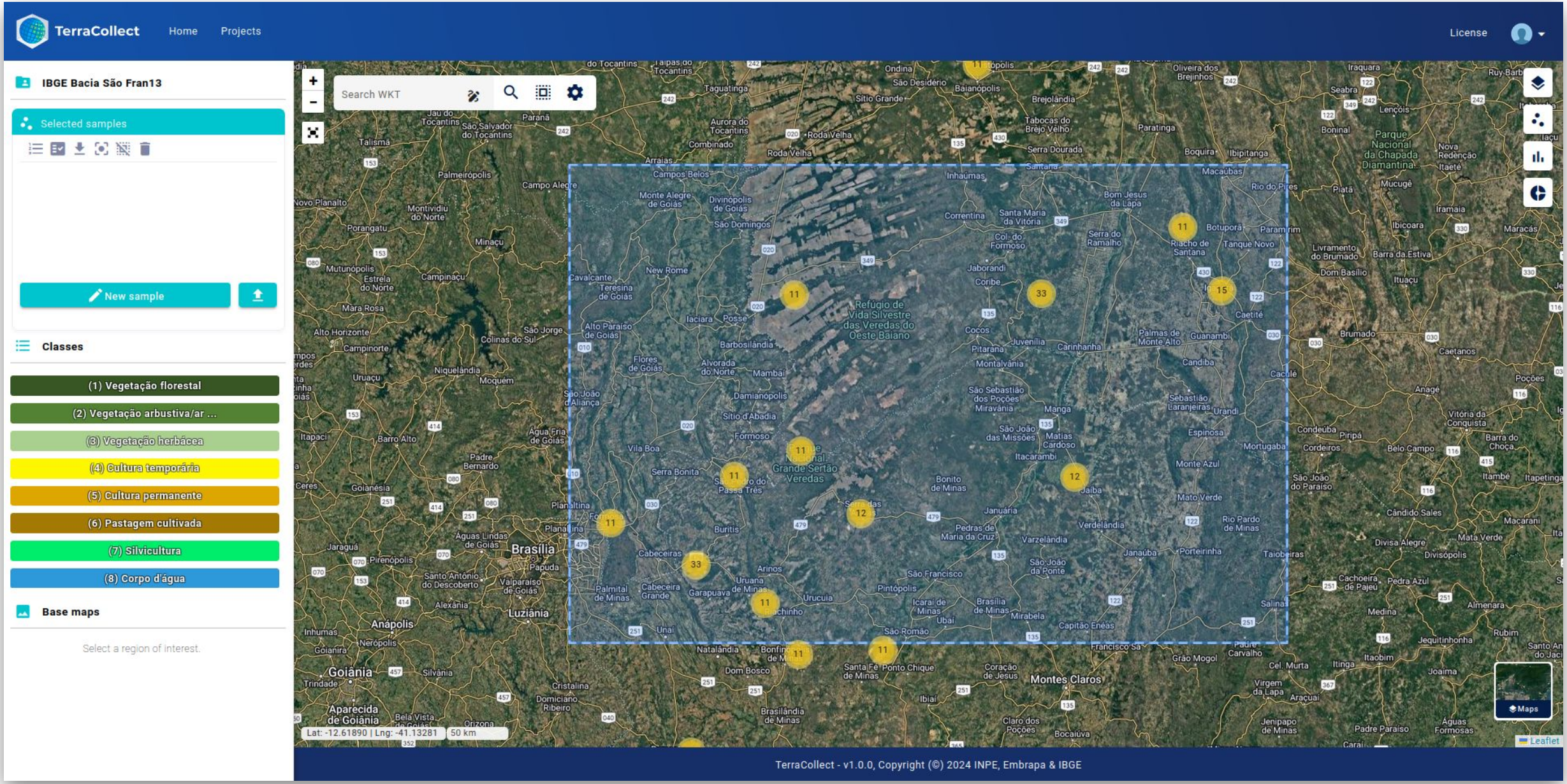
Edit the RGB composition from the cubes and image collections

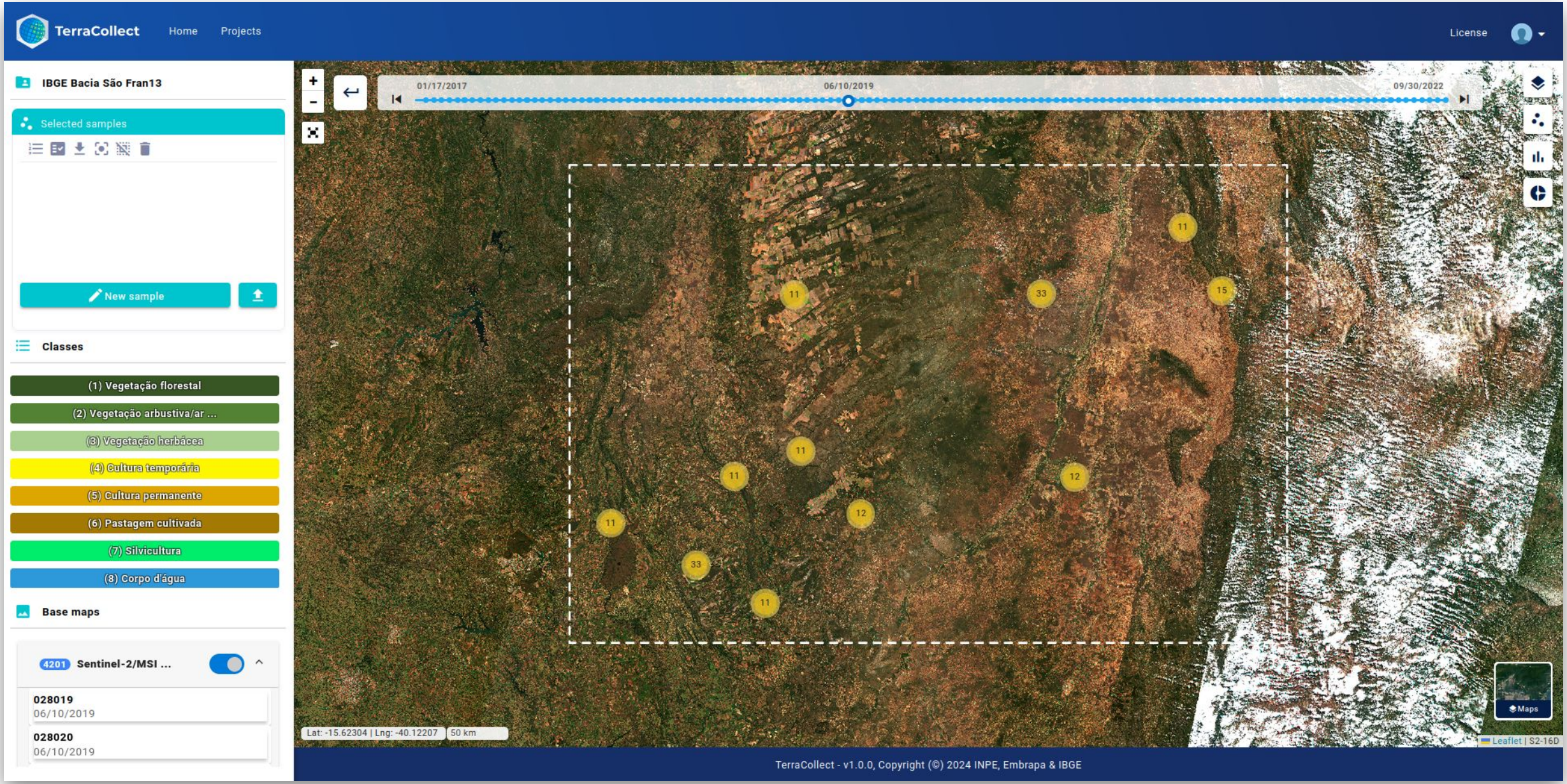
View time series and land trajectory graphs

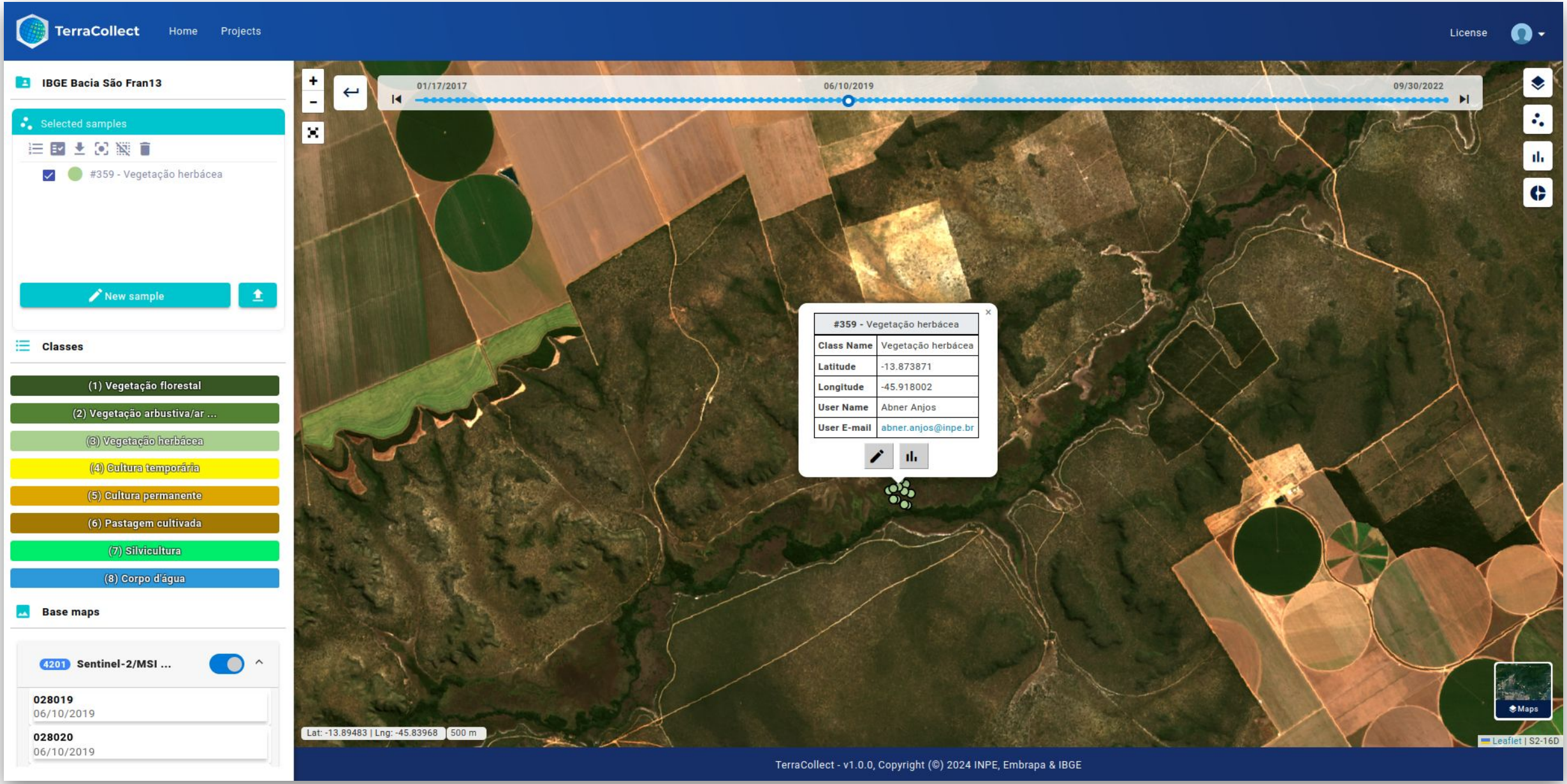


View external maps such as PRODES, TerraClass e MapBiomas


TerraCollect
Home
License
Projects
Coleta Gabriel 2024
IBGE Bacia São Fran19
IBGE Bacia São Fran18
IBGE Bacia São Fran17
IBGE Bacia São Fran16
IBGE Bacia São Fran15
IBGE Bacia São Fran14
IBGE Bacia São Fran13
IBGE Bacia São Fran12
IBGE Bacia São Fran11
IBGE Bacia São Fran10
IBGE Bacia São Fran 9
IBGE Bacia São Fran 8
Open
Colômbia
Suriname
Francesa
Boa Vista
RORAIMA
AMAPÁ
Macapá
Quito
Equador
Guaiaquil
Cuenca
Manaus
Santarém
Belém
São Luís
AMAZONAS
PARÁ
MARANHÃO
Imperatriz
CEARÁ
RIO GRANDE DO NORTE
PARAÍBA
João Pessoa
PIAUÍ
PERNAMBUCO
Trujillo
Porto Velho
Brasil
ACRE
Peru
Lima
RONDÔNIA
Palmas
TOCANTINS
ALAGOAS
SERGIPE
BAHIA
Salvador
Cusco
MATO GROSSO
Cuiabá
GOIÁS
Brasília
Goiânia
Arequipa
La Paz
Bolívia
Cochabamba
MINAS GERAIS
Santa Cruz de La Sierra
Sucre
Uberlândia
Belo Horizonte
ESPÍRITO SANTO
Campo Grande
Ribeirão Preto
MATO GROSSO DO SUL
RIO DE JANEIRO
SÃO PAULO
São Paulo
Rio de Janeiro
JUJUY
Antofagasta
Paraguai
PARANÁ
Curitiba
SALTA
FORMOSA
Chile
CHACO
CATAMARCA
MISIONES
SANTA CATARINA
Florianópolis
SANTIAGO DEL ESTERO
CORRIENTES
RIO GRANDE DO SUL
RIOJA
SANTA FÉ
Porto Alegre
SAN JUAN
Córdova
CÓRDOVA
ENTRE RÍOS
Uruguai
Santiago
Mendoza
Rosário
SAN LUIS
Oceano Atlântico
Lat: -17.64402 | Lng: -13.71094
300 km
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

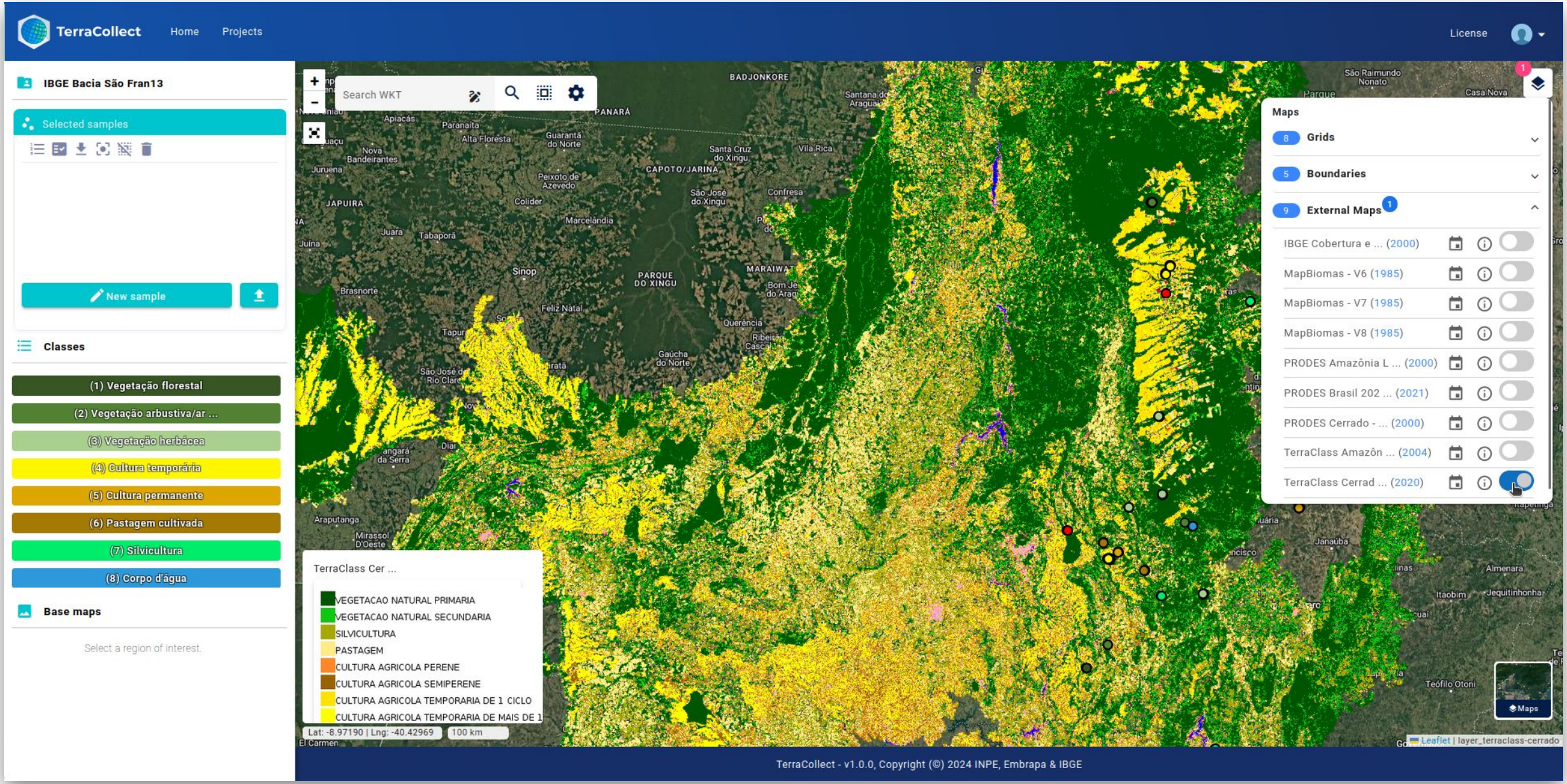

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Refúgio de Vida Silvestre das Veredas do Oeste Baiano
Parque Nacional Grande Sertão Veredas
Brasília
Goiânia
Anápolis
Montes Claros
Lat: -12.61890 | Lng: -41.13281
50 km
Maps
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

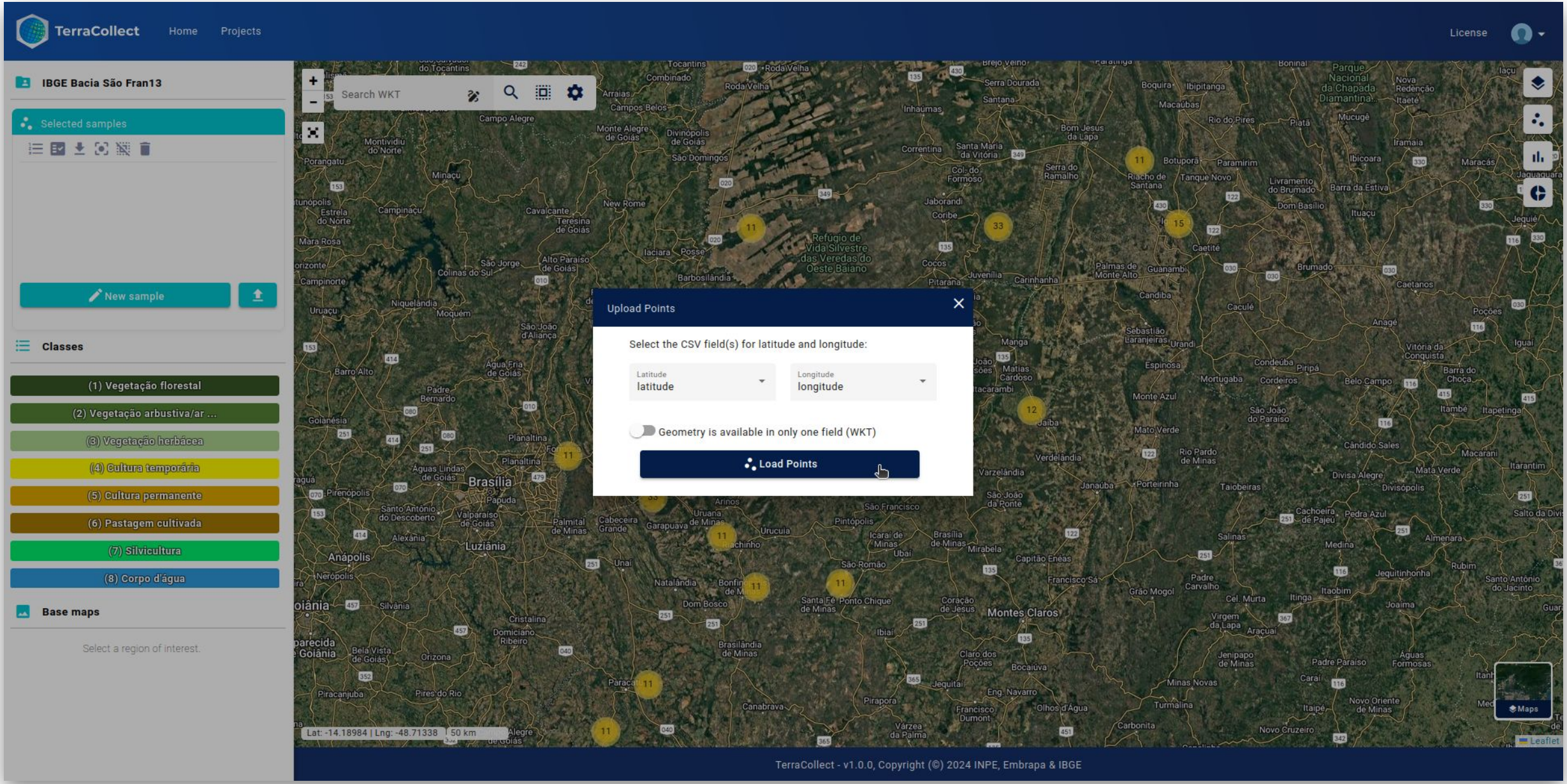

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
4201 Sentinel-2/MSI ...
028019
06/10/2019
028020
06/10/2019
01/17/2017
06/10/2019
09/30/2022
Lat: -15.62304 | Lng: -40.12207
50 km
Maps
Leaflet | S2-16D
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

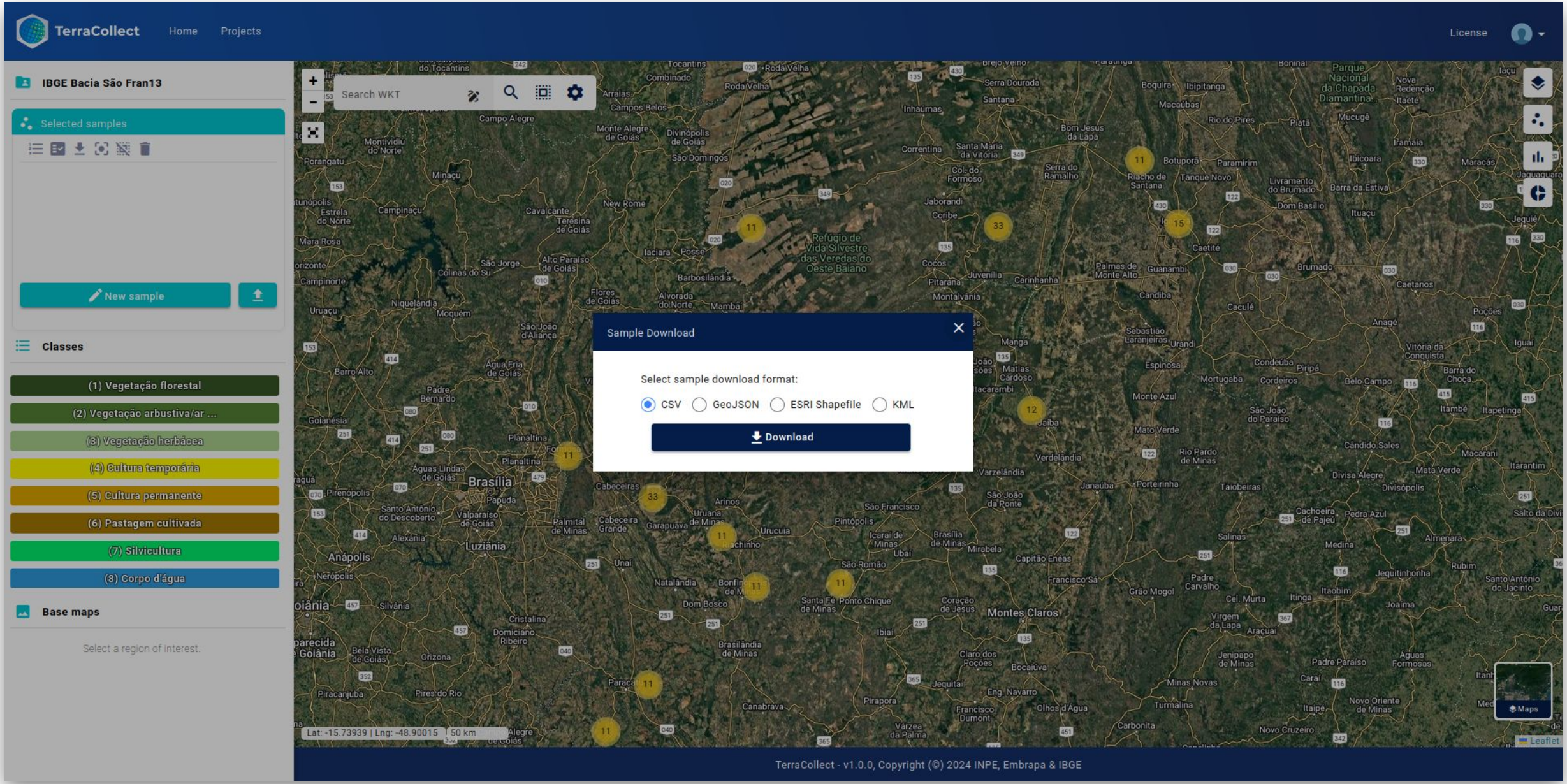

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
#359 - Vegetação herbácea
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
4201 Sentinel-2/MSI ...
028019
06/10/2019
028020
06/10/2019
01/17/2017
06/10/2019
09/30/2022
#359 - Vegetação herbácea
Class Name Vegetação herbácea
Latitude -13.873871
Longitude -45.918002
User Name Abner Anjos
User E-mail abner.anjos@inpe.br
Lat: -13.89483 | Lng: -45.83968
500 m
Maps
Leaflet | S2-16D
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

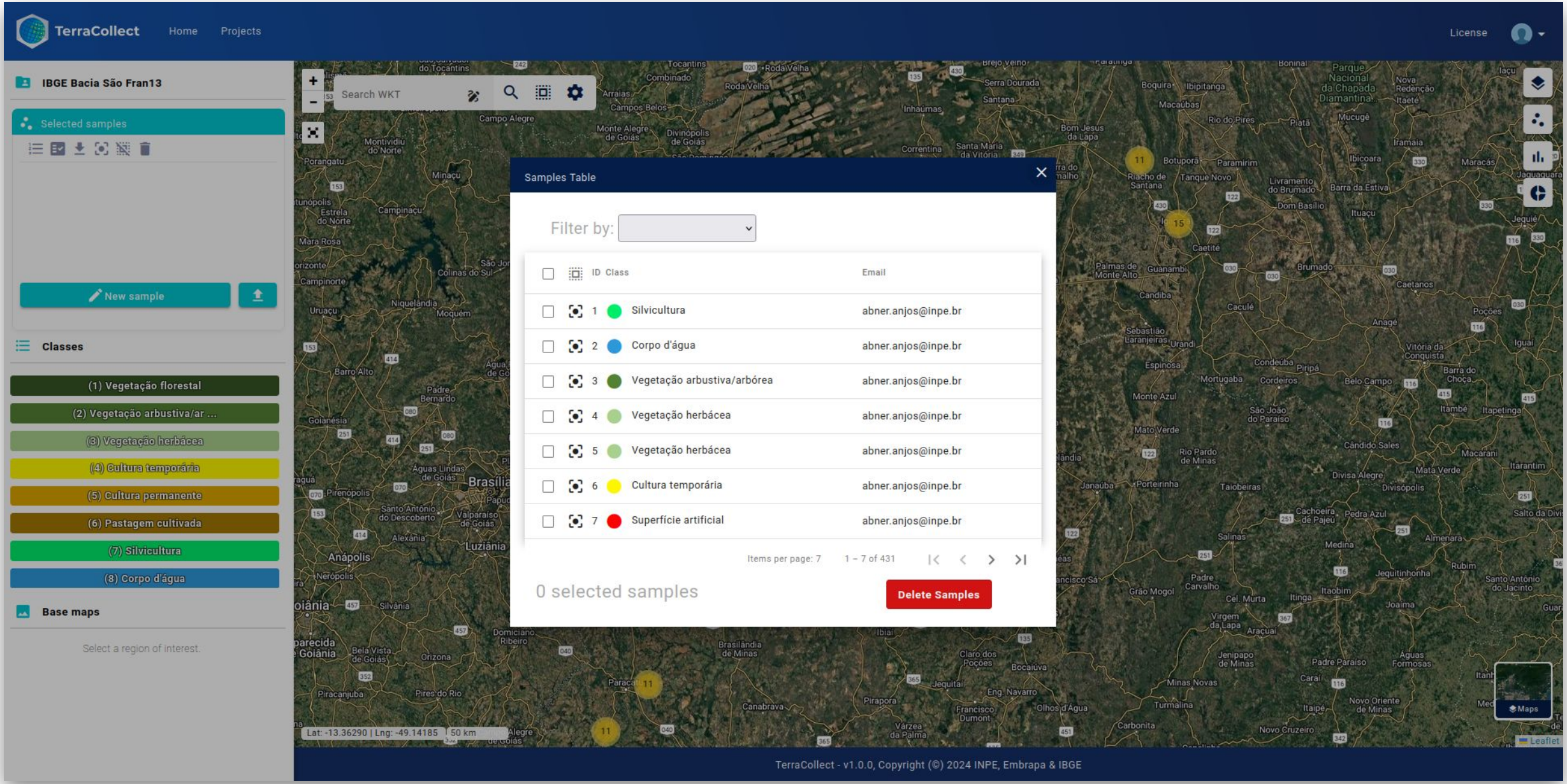

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
2315 Sentinel-2/MSI ...
031019
06/26/2019
031020
06/26/2019
01/17/2017
06/26/2019
09/30/2022
Lat: -13.93240 | Lng: -43.65555
3 km
Leaflet | S2-16D
Point: -43.954582214355476 -13.891744373921862
Land Trajectory
2000
2005
2010
2015
2020
Terraclass Am.. :No-Data
Mapbiomas V8:Formação Savânica
Ibge Cobertur.. :Vegetação Florestal
Time series
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
EVI:S2-16D-2
NDVI:S2-16D-2
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

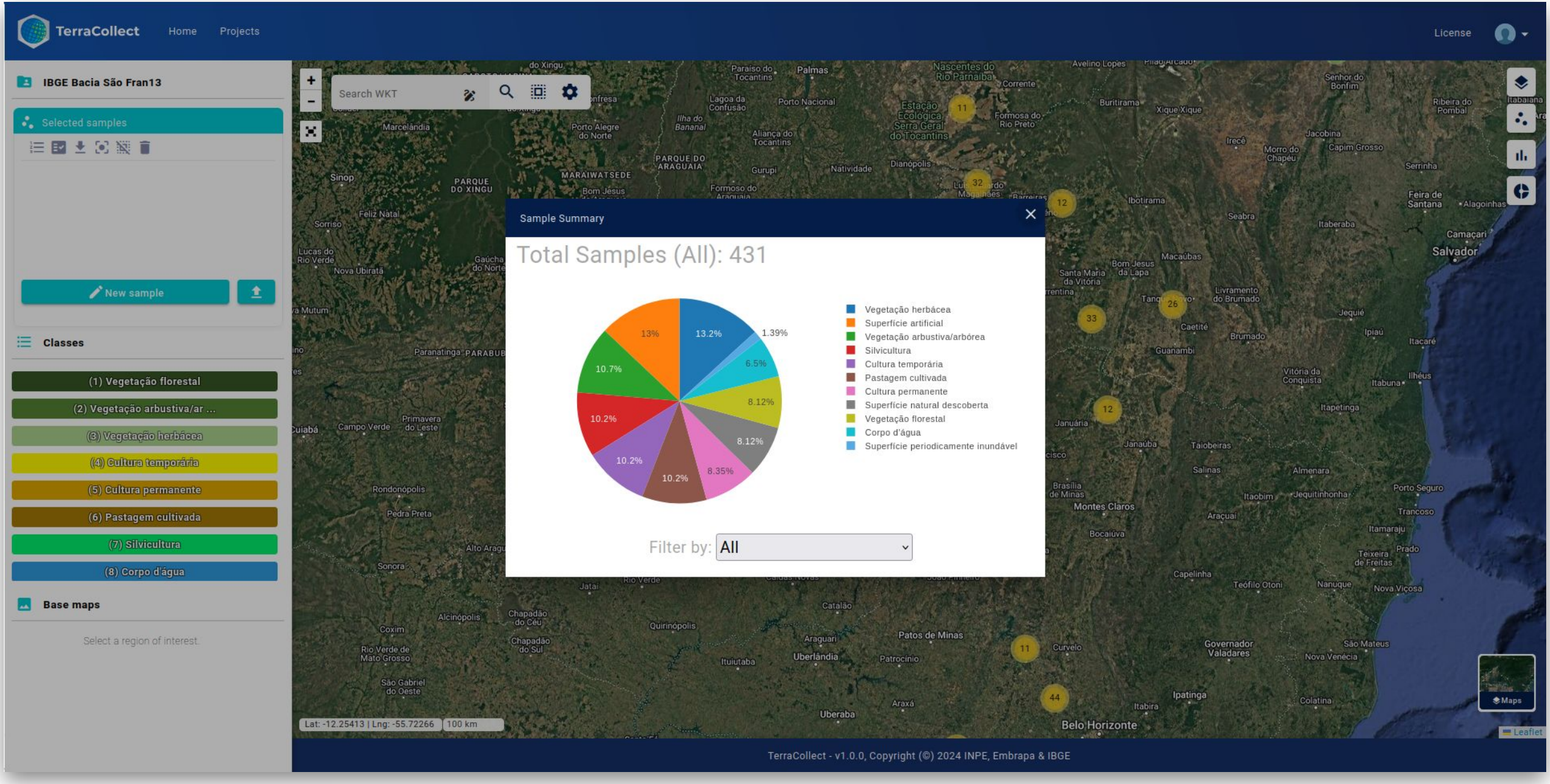

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
#359 - Vegetação herbácea
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
4201 Sentinel-2/MSI ...
028019
06/10/2019
028020
06/10/2019
01/17/2017
06/10/2019
09/30/2022
#359 - Vegetação herbácea
Class Name Vegetação herbácea
Latitude -13.873871
Longitude -45.918002
User Name Abner Anjos
User E-mail abner.anjos@inpe.br
Lat: -13.86908 | Lng: -45.83917
500 m
Leaflet | S2-16D
Point: -45.918002 -13.873871
Land Trajectory
2000
2005
2010
2015
2020
Terraclass Am.. :No-Data
Mapbiomas V8:Formação Campestre
Ibge Cobertur.. :Vegetação Campestre
Time series
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
2017
2018
2019
2020
2021
2022
2023
2024
EVI:S2-16D-2
NDVI:S2-16D-2
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

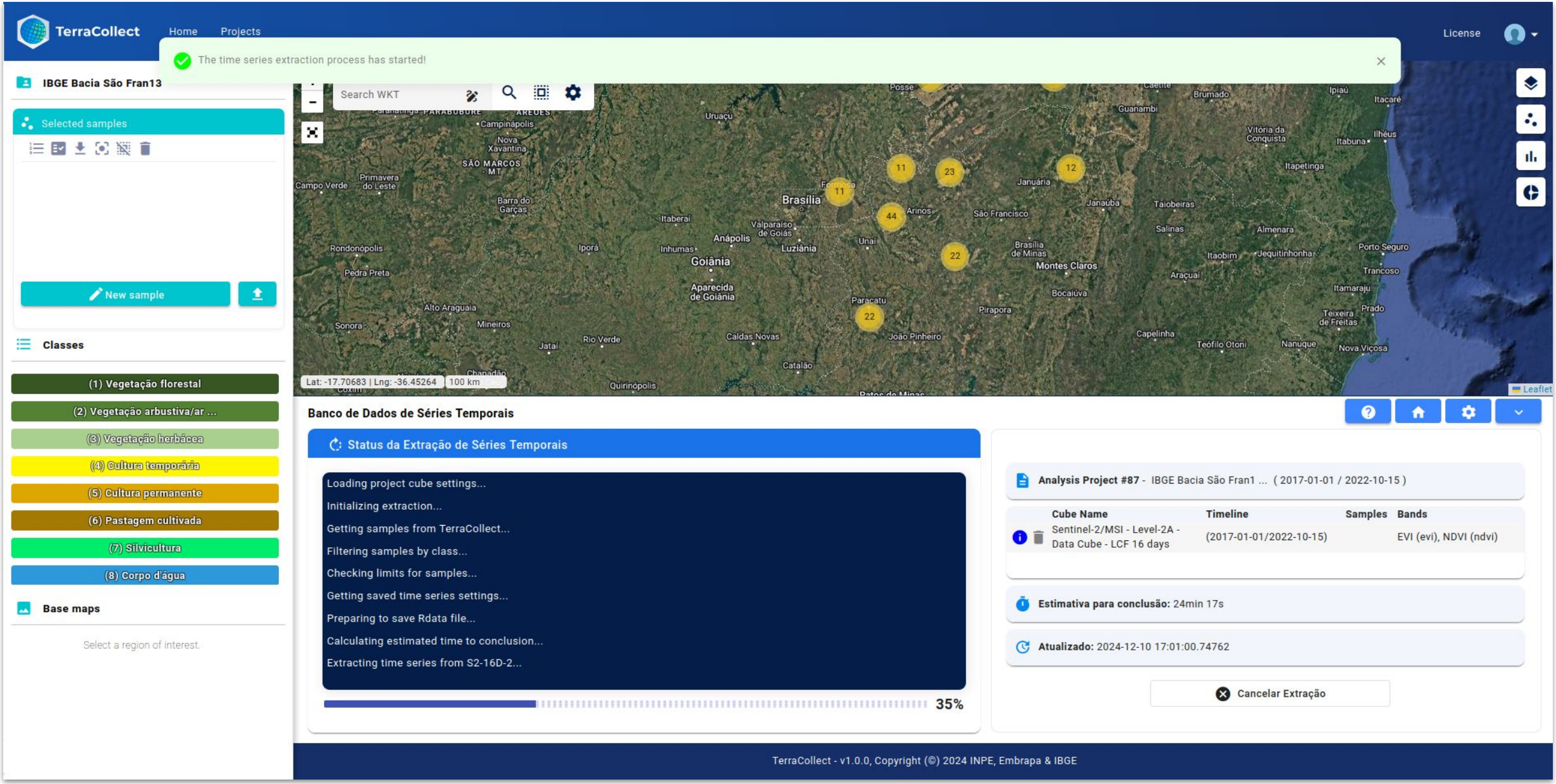

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Maps
Grids
Boundaries
External Maps
IBGE Cobertura e ... (2000)
MapBiomas - V6 (1985)
MapBiomas - V7 (1985)
MapBiomas - V8 (1985)
PRODES Amazônia L ... (2000)
PRODES Brasil 202 ... (2021)
PRODES Cerrado - ... (2000)
TerraClass Amazôn ... (2004)
TerraClass Cerrad ... (2020)
TerraClass Cer ...
VEGETACAO NATURAL PRIMARIA
VEGETACAO NATURAL SECUNDARIA
SILVICULTURA
PASTAGEM
CULTURA AGRICOLA PERENE
CULTURA AGRICOLA SEMIPERENE
CULTURA AGRICOLA TEMPORARIA DE 1 CICLO
CULTURA AGRICOLA TEMPORARIA DE MAIS DE 1
Lat: -8.97190 | Lng: -40.42969
100 km
Leaflet | layer_terraclass-cerrado
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

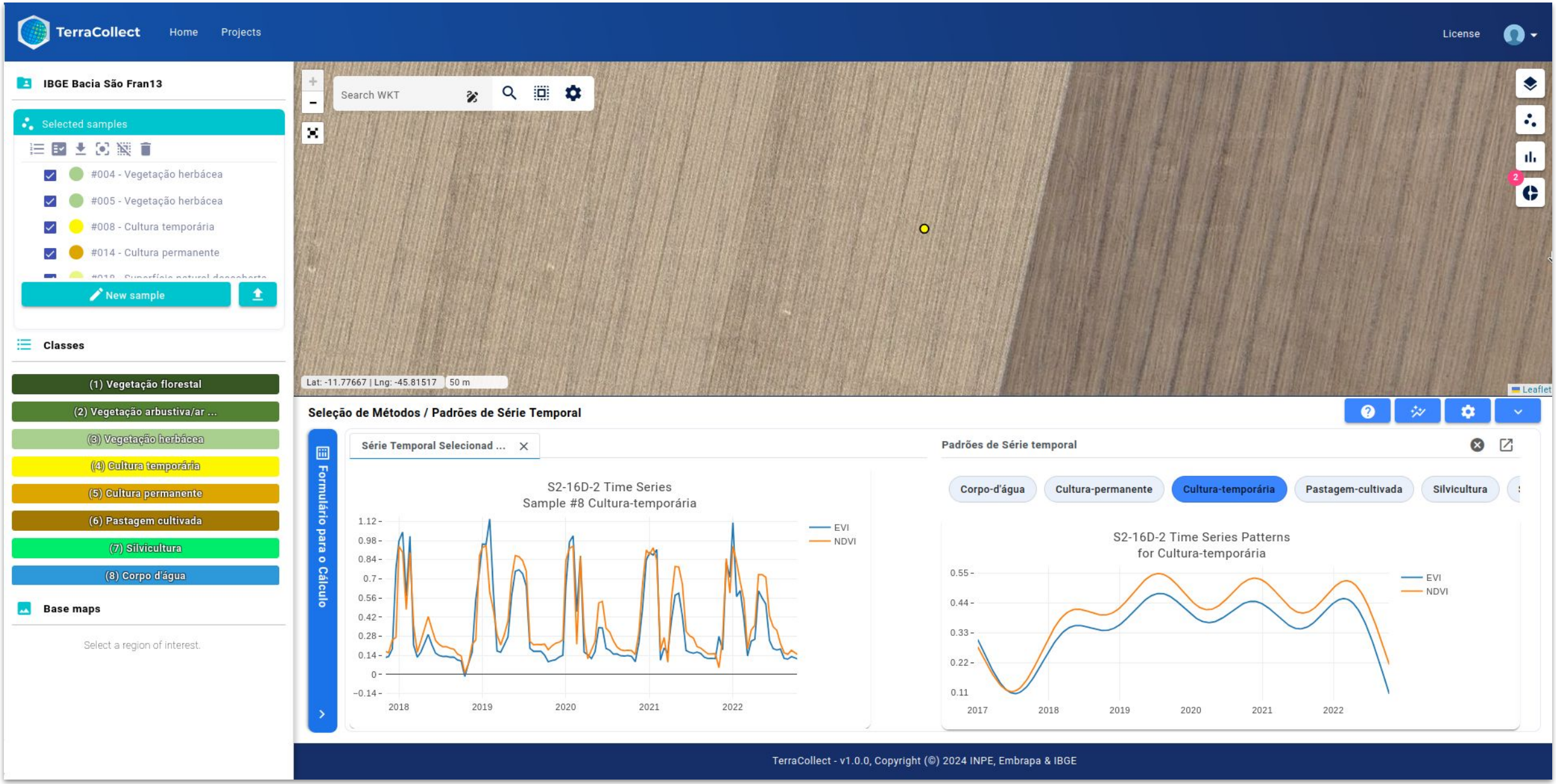

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Upload Points
Select the CSV field(s) for latitude and longitude:
Latitude
latitude
Longitude
longitude
Geometry is available in only one field (WKT)
Load Points
Brasília
Anápolis
Luziânia
Montes Claros
Lat: -14.18984 | Lng: -48.71338
50 km
Maps
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

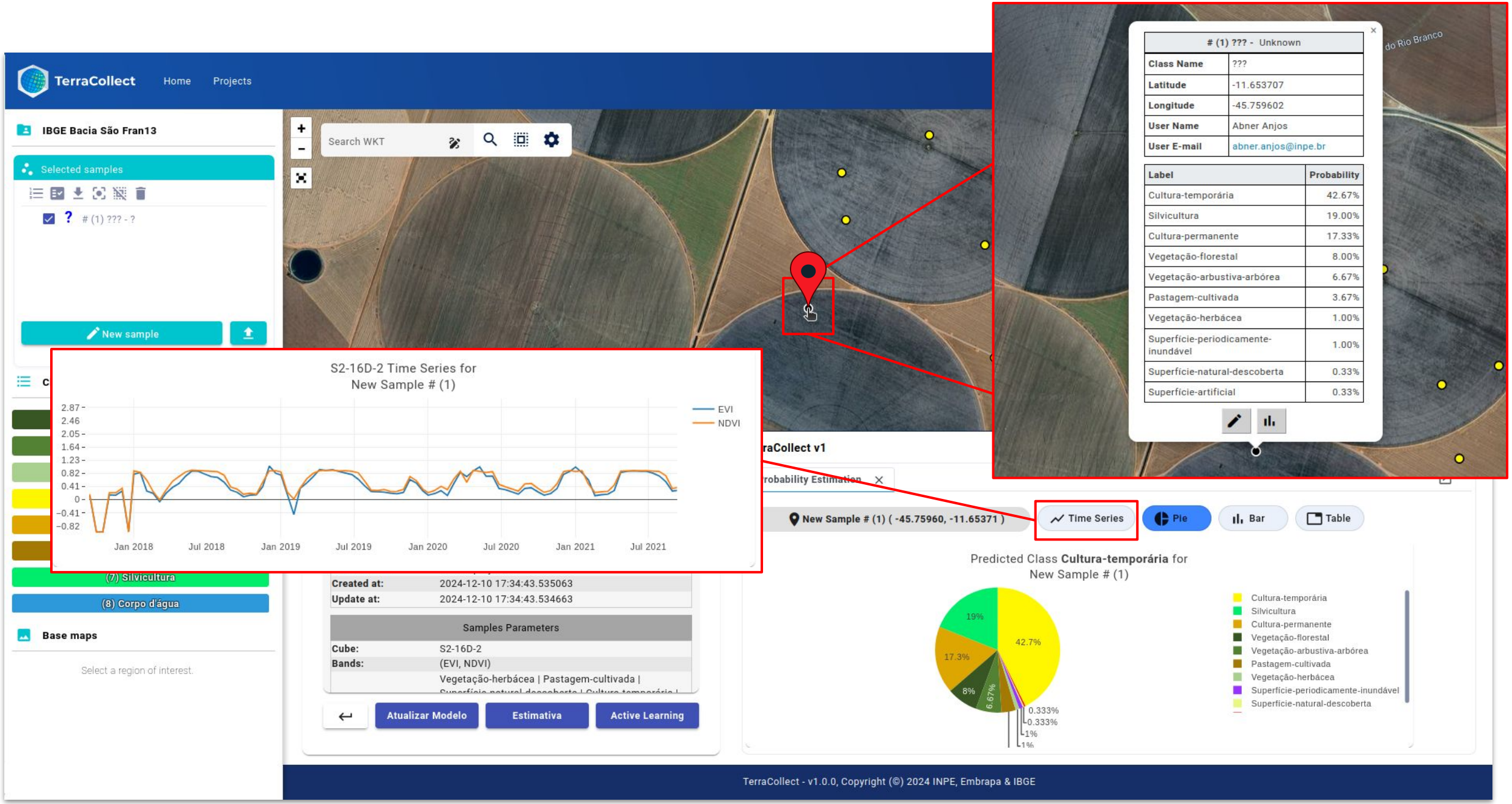

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Sample Download
Select sample download format:
CSV
GeoJSON
ESRI Shapefile
KML
Download
Brasília
Anápolis
Luziânia
Montes Claros
Lat: -15.73939 | Lng: -48.90015
50 km
Maps
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE


TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Samples Table
Filter by:
ID Class
Email
1 Silvicultura abner.anjos@inpe.br
2 Corpo d'água abner.anjos@inpe.br
3 Vegetação arbustiva/arbórea abner.anjos@inpe.br
4 Vegetação herbácea abner.anjos@inpe.br
5 Vegetação herbácea abner.anjos@inpe.br
6 Cultura temporária abner.anjos@inpe.br
7 Superfície artificial abner.anjos@inpe.br
Items per page: 7
1 – 7 of 431
0 selected samples
Delete Samples
Lat: -13.36290 | Lng: -49.14185
50 km
Maps
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE


TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest
Search WKT
Sample Summary
Total Samples (All): 431
13.2%
1.39%
6.5%
8.12%
8.12%
8.35%
10.2%
10.2%
10.2%
10.7%
13%
Vegetação herbácea
Superfície artificial
Vegetação arbustiva/arbórea
Silvicultura
Cultura temporária
Pastagem cultivada
Cultura permanente
Superfície natural descoberta
Vegetação florestal
Corpo d'água
Superfície periodicamente inundável
Filter by:
All
Lat: -12.25413 | Lng: -55.72266
100 km
Maps
Leaflet
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

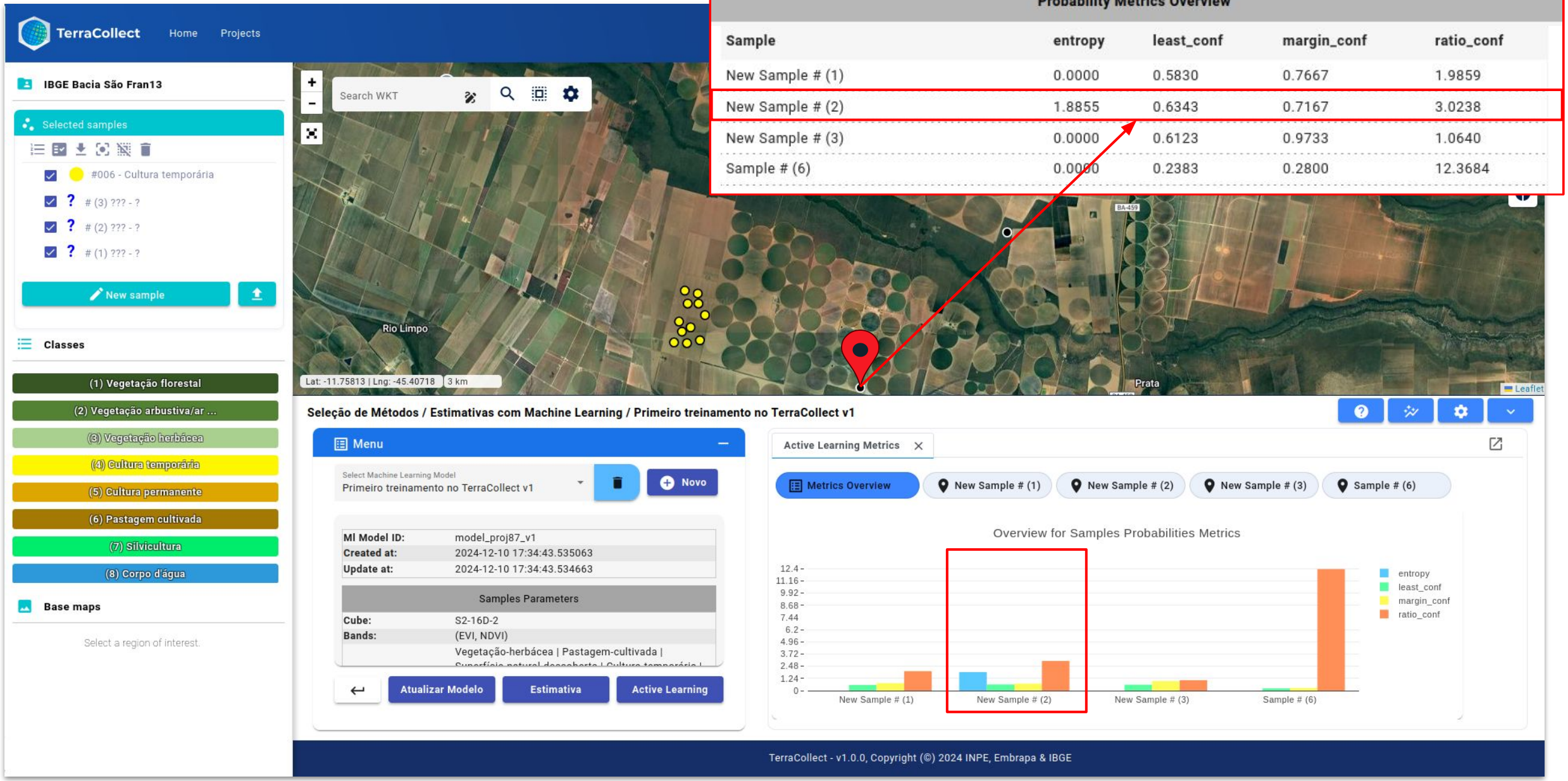

TerraCollect
Home
Projects
License
The time series extraction process has started!
IBGE Bacia São Fran13
Selected samples
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Brasília
Goiânia
Anápolis
Luziânia
Rio Verde
Caldas Novas
Montes Claros
Lat: -17.70683 | Lng: -36.45264
100 km
Leaflet
Banco de Dados de Séries Temporais
Status da Extração de Séries Temporais
Loading project cube settings...
Initializing extraction...
Getting samples from TerraCollect...
Filtering samples by class...
Checking limits for samples...
Getting saved time series settings...
Preparing to save Rdata file...
Calculating estimated time to conclusion...
Extracting time series from S2-16D-2...
35%
Analysis Project #87 - IBGE Bacia São Fran1 ... (2017-01-01 / 2022-10-15)
Cube Name
Timeline
Samples
Bands
Sentinel-2/MSI - Level-2A - Data Cube - LCF 16 days
(2017-01-01/2022-10-15)
EVI (evi), NDVI (ndvi)
Estimativa para conclusão: 24min 17s
Atualizado: 2024-12-10 17:01:00.74762
Cancelar Extração
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

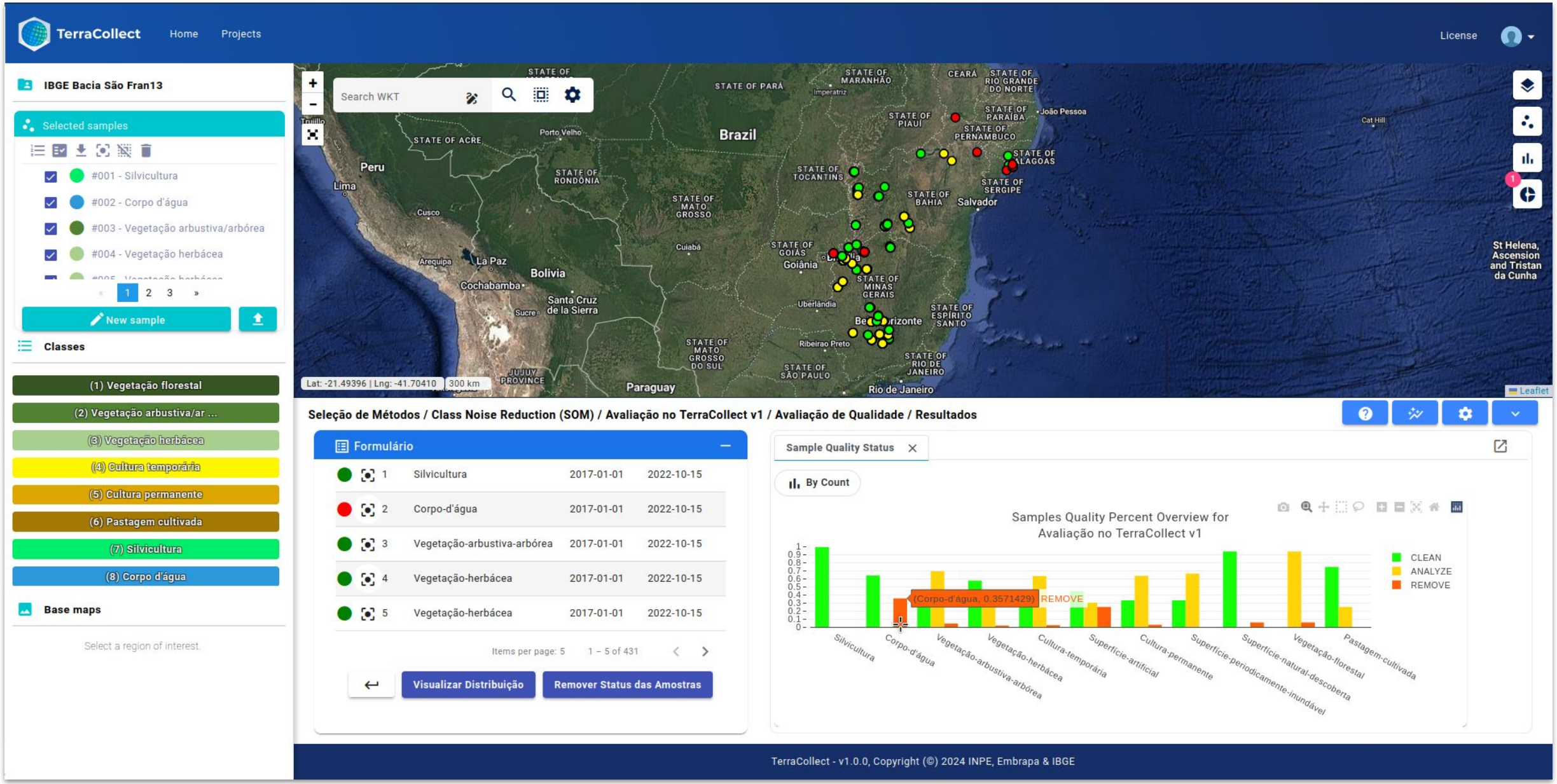

TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
#004 - Vegetação herbácea
#005 - Vegetação herbácea
#008 - Cultura temporária
#014 - Cultura permanente
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Lat: -11.77667 | Lng: -45.81517
50 m
Leaflet
Seleção de Métodos / Padrões de Série Temporal
Formulário para o Cálculo
Série Temporal Selecionad ...
S2-16D-2 Time Series
Sample #8 Cultura-temporária
EVI
NDVI
Padrões de Série temporal
Corpo-d'água
Cultura-permanente
Cultura-temporária
Pastagem-cultivada
Silvicultura
S2-16D-2 Time Series Patterns
for Cultura-temporária
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE


TerraCollect
Home
Projects
IBGE Bacia São Fran13
Selected samples
(1) ??? - ?
New sample
Search WKT
S2-16D-2 Time Series for
New Sample # (1)
EVI
NDVI
2.87
2.46
2.05
1.64
1.23
0.82
0.41
0
−0.41
−0.82
Jan 2018
Jul 2018
Jan 2019
Jul 2019
Jan 2020
Jul 2020
Jan 2021
Jul 2021
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
(1) ??? - Unknown
Class Name ???
Latitude -11.653707
Longitude -45.759602
User Name Abner Anjos
User E-mail abner.anjos@inpe.br
Label Probability
Cultura-temporária 42.67%
Silvicultura 19.00%
Cultura-permanente 17.33%
Vegetação-florestal 8.00%
Vegetação-arbustiva-arbórea 6.67%
Pastagem-cultivada 3.67%
Vegetação-herbácea 1.00%
Superfície-periodicamente-inundável 1.00%
Superfície-natural-descoberta 0.33%
Superfície-artificial 0.33%
raCollect v1
robability Estimation
New Sample # (1) (-45.75960, -11.65371)
Time Series
Pie
Bar
Table
Created at: 2024-12-10 17:34:43.535063
Update at: 2024-12-10 17:34:43.534663
Samples Parameters
Cube: S2-16D-2
Bands: (EVI, NDVI)
Vegetação-herbácea | Pastagem-cultivada |
Atualizar Modelo
Estimativa
Active Learning
Predicted Class Cultura-temporária for
New Sample # (1)
42.7%
19%
17.3%
8%
6.67%
0.333%
0.333%
1%
1%
Cultura-temporária
Silvicultura
Cultura-permanente
Vegetação-florestal
Vegetação-arbustiva-arbórea
Pastagem-cultivada
Vegetação-herbácea
Superfície-periodicamente-inundável
Superfície-natural-descoberta
TerraCollect - v1.0.0, Copyright (©) 2024 INPE, Embrapa & IBGE

Probability Metrics Overview

Sample	entropy	least_conf	margin_conf	ratio_conf
New Sample # (1)	0.0000	0.5830	0.7667	1.9859
New Sample # (2)	1.8855	0.6343	0.7167	3.0238
New Sample # (3)	0.0000	0.6123	0.9733	1.0640
Sample # (6)	0.0000	0.2383	0.2800	12.3684




TerraCollect
Home
Projects
License
IBGE Bacia São Fran13
Selected samples
#001 - Silvicultura
#002 - Corpo d'água
#003 - Vegetação arbustiva/arbórea
#004 - Vegetação herbácea
1 2 3
New sample
Classes
(1) Vegetação florestal
(2) Vegetação arbustiva/ar ...
(3) Vegetação herbácea
(4) Cultura temporária
(5) Cultura permanente
(6) Pastagem cultivada
(7) Silvicultura
(8) Corpo d'água
Base maps
Select a region of interest.
Search WKT
Brazil
Peru
Bolivia
Paraguay
Lima
La Paz
Cochabamba
Santa Cruz de la Sierra
Salvador
Goiânia
Rio de Janeiro
Lat: -21.49396 | Lng: -41.70410
300 km
Leaflet
Seleção de Métodos / Class Noise Reduction (SOM) / Avaliação no TerraCollect v1 / Avaliação de Qualidade / Resultados
Formulário
1 Silvicultura 2017-01-01 2022-10-15
2 Corpo-d'água 2017-01-01 2022-10-15
3 Vegetação-arbustiva-arbórea 2017-01-01 2022-10-15
4 Vegetação-herbácea 2017-01-01 2022-10-15
5 Vegetação-herbácea 2017-01-01 2022-10-15
Items per page: 5
1 – 5 of 431
Visualizar Distribuição
Remover Status das Amostras
Sample Quality Status
By Count
Samples Quality Percent Overview for Avaliação no TerraCollect v1
(Corpo-d'água, 0.3571429) REMOVE
CLEAN
ANALYZE
REMOVE
Silvicultura
Corpo-d'água
Vegetação-arbustiva-arbórea
Vegetação-herbácea
Cultura-temporária
Superfície-artificial
Cultura-permanente
Superfície-periodicamente-inundável
Superfície-natural-descoberta
Vegetação-florestal
Pastagem-cultivada
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BDC Lab

Interactive computing

JupyterLab

brazildatacube.dpi.inpe.br/jupyter-e003/user/efelipecarlos_at_gmail.com/lab?

File Edit View Run Kernel Tabs Settings Help

02_CB4_64_16D_STK-1_CI

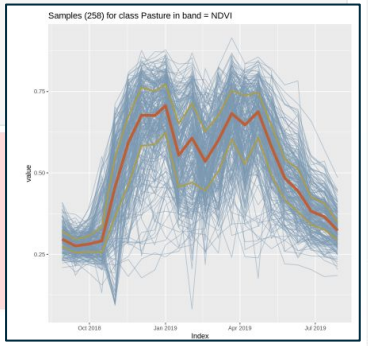
Markdown SITS

Classify the datacube

> This is a time-consuming process

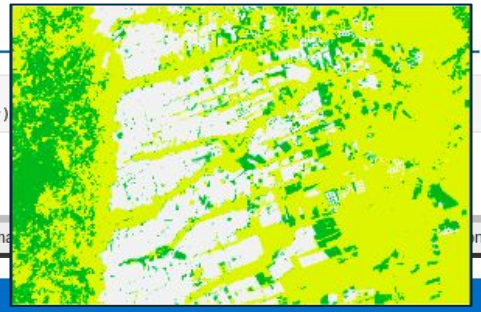
[9]:
```
probs <- sits_classify(data       = cube,
                       ml_model   = dl_model,
                       memsize    = classification_memsize,
                       multicores = classification_multicores,
                       roi        = roi$classification_roi,
                    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



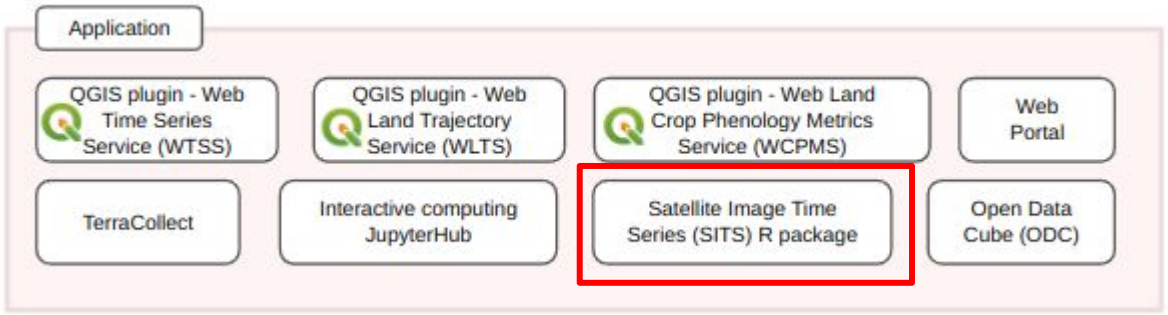
Generate classification label map

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



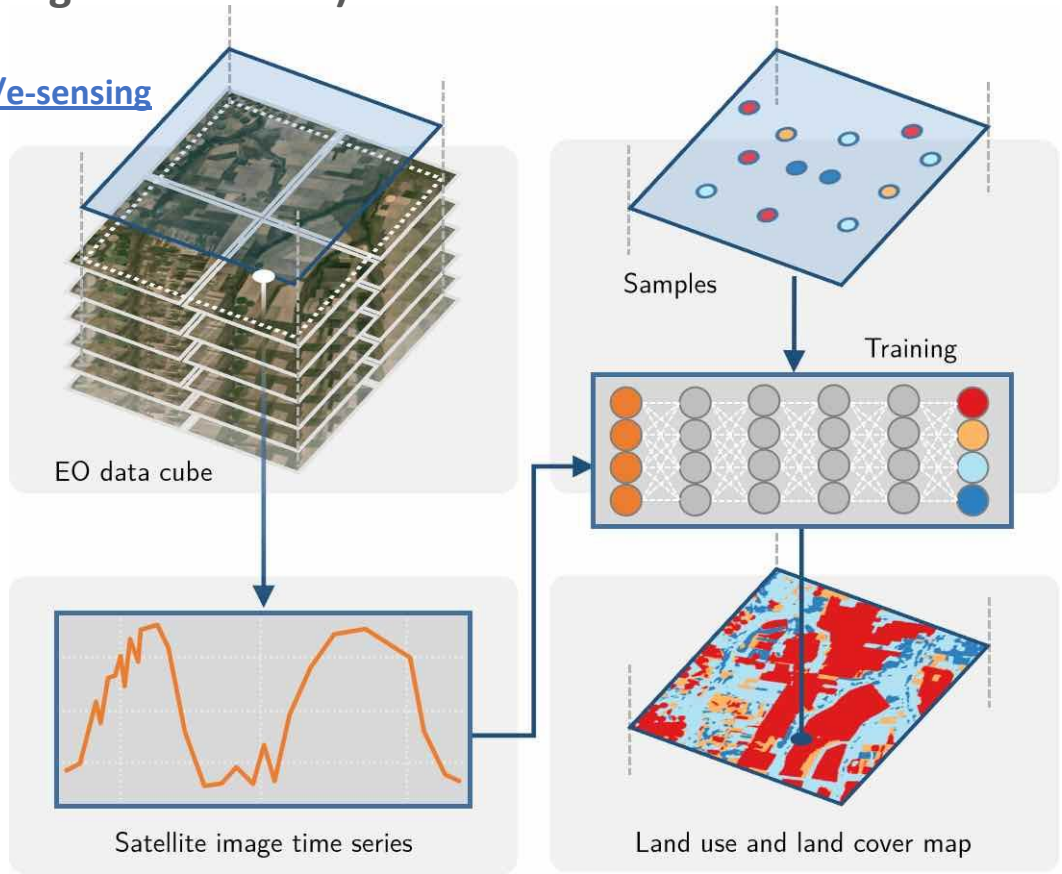
Visualizing classification map

0 2 No Kernel | Idle Saving completed Mode: Comma n.ipynb

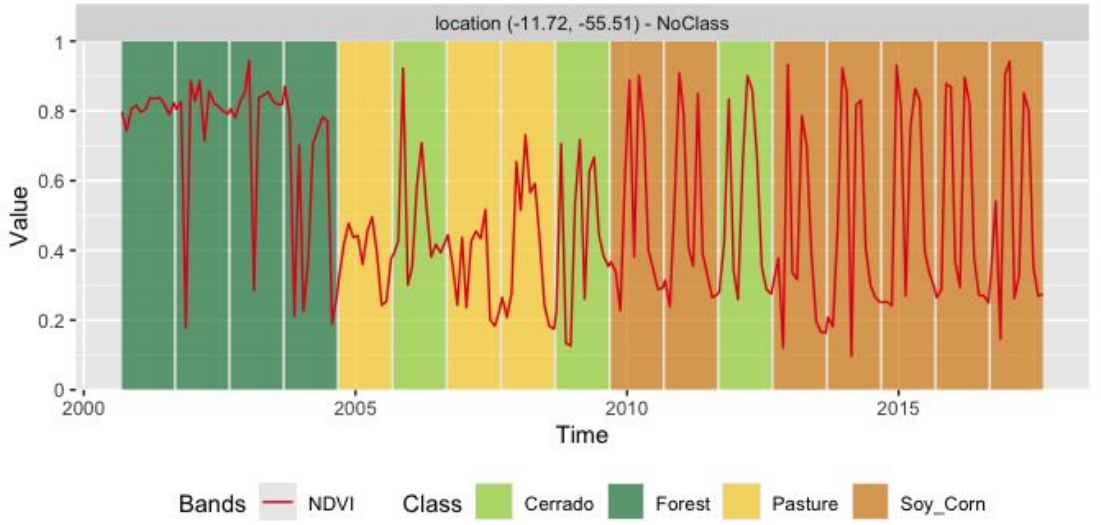


SITS (Satellite Image Time Series) R package

https://github.com/e-sensing




```r
# training data set
data("samples_modis_ndvi")
# point to be classified
data("point_mt_6bands")
# Train a deep learning model
tempcnn_model <- sits_train(
  samples = samples_modis_ndvi,
  ml_method = sits_tempcnn()
)
# Select NDVI band of the  point to be classified
# Classify using TempCNN model
# Plot the result
point_mt_6bands |>
  sits_select(bands = "NDVI") |>
  sits_classify(tempcnn_model) |>
  plot()
```



Links úteis

Brazil Data Cube: https://data.inpe.br/bdc/web

Brazil Data Cube **Explorer**: https://data.inpe.br/bdc/explorer

Brazil Data Cube **Github.io**: https://brazil-data-cube.github.io

Brazil Data Cube **Github**: https://github.com/brazil-data-cube

Brazil Data Cube Github **Code Gallery Repository**: https://github.com/brazil-data-cube/code-gallery

INPE **STAC Browser**: https://data.inpe.br/stac/browser

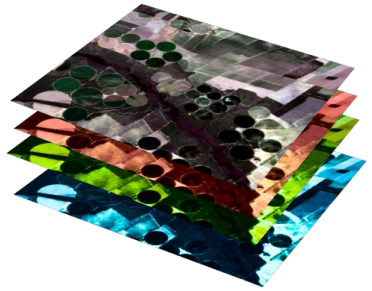
Fluxo

STAC

Buscar imagens

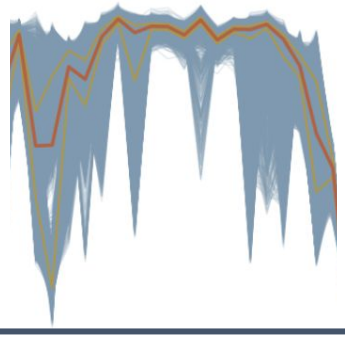
Catalog Database

Visualizar
(True Color e False Color)

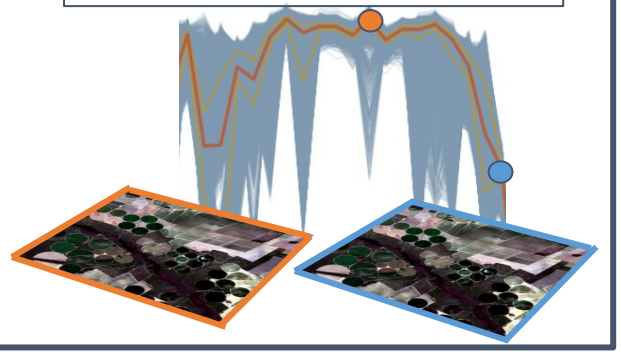


WTSS

Obter uma série temporal

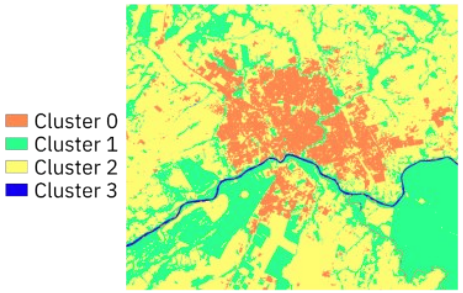


Visualizar imagem do pico e do vale da série temporal para análise

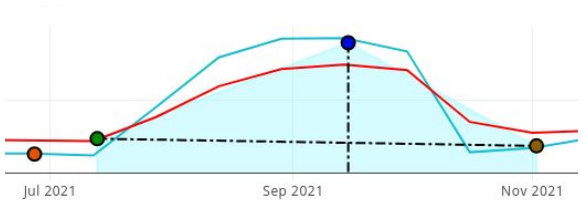


Clusterização

Map with 4 clusters



Extração de métricas fenológicas

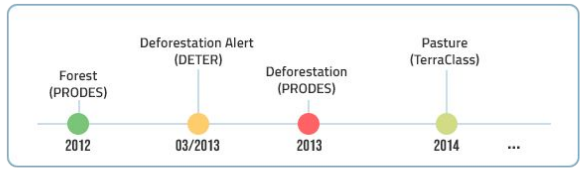


WLTS

Comparação com projetos existentes

TerraClass

MAPBIOMAS



BRAZIL DATA CUBE
brazildatacube.org

http://brazildatacube.org

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

SBSR
XXI SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO

Obrigado!

bdc.team@inpe.br

@brazildatacube

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