

Use of time series of remote sensing imagery for Land Use monitoring

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Overview

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Computing platforms

Programming languages

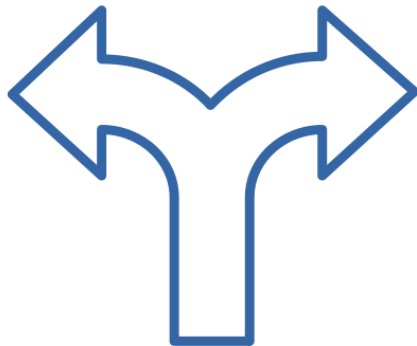
Results

Conclusions

Introduction

Brazil is at a crossroad

- ▶ Food production versus environment conservation [Garnett, 2011].
- ▶ Brazil is one of the largest food producers.
- ▶ Brazil hosts over 60% of Amazonia.



Remote Sensing

- ▶ Remote Sensing is still the best way to water data about Land Use and Land Cover Change [Picoli et al., 2018].
- ▶ Traditionally, RS has been an human-expert intensive activity.
- ▶ Use of remote sensing imagery for conservation efforts.
- ▶ Traditionally, remote sensing has focus on small areas.
- ▶ Pre-processing imagery is resource intensive.

Analysis Ready Data

- ▶ Satellite data processed.
- ▶ Allows immediate analysis.
- ▶ Minimum user effort.
- ▶ Interoperability through time.
- ▶ Interoperability with other data sets [Siqueira et al., 2019].

CEOS ANALYSIS READY DATA FOR LAND – AN OVERVIEW ON THE CURRENT AND FUTURE WORK

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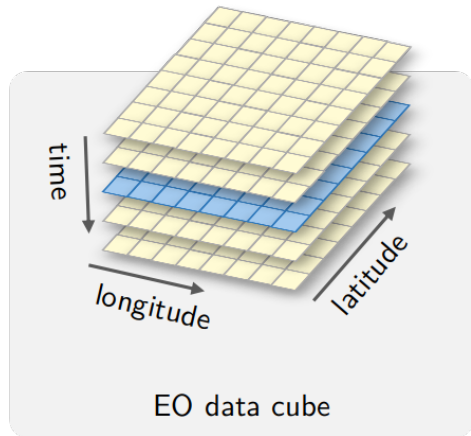
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Data Cube

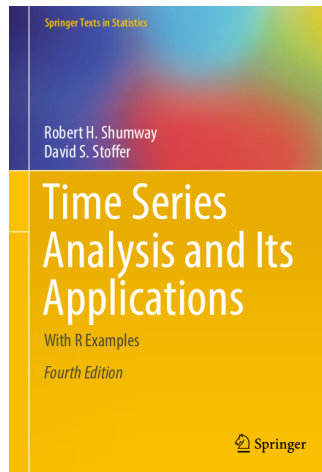
- ▶ A regular, dense, four-dimensional data structure [Appel and Pebesma, 2019].
- ▶ Data cube dimensions refer to the same spatial, temporal, and thematic reference systems.
- ▶ Data Cube cells have the same size and duration.
- ▶ Cells are aligned.
- ▶ A cell has a unique value.



Source [Gilberto Camara et al., 2023].

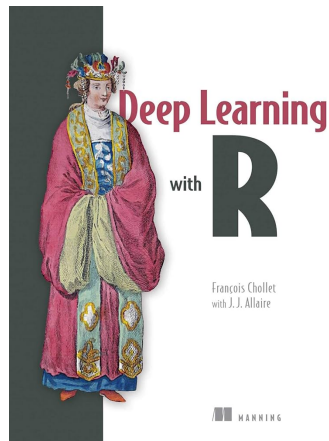
Time series analysis

- ▶ Times series are experimental data observed at different points in time.
- ▶ *Time series analysis is a systematic approach by which one goes about answering the mathematical and statistical questions posed by time correlations [Shumway and Stoffer, 2017].*



Deep learning

- ▶ Artificial intelligence is the effort to automate intellectual tasks normally performed by humans.
- ▶ Machine Learning discovers rules to execute a data-processing task, given examples of what's expected.
- ▶ Deep Learning is a mathematical framework for learning representations from data using successive layers of increasingly meaningful representations [Chollet and Allaire, 2018].



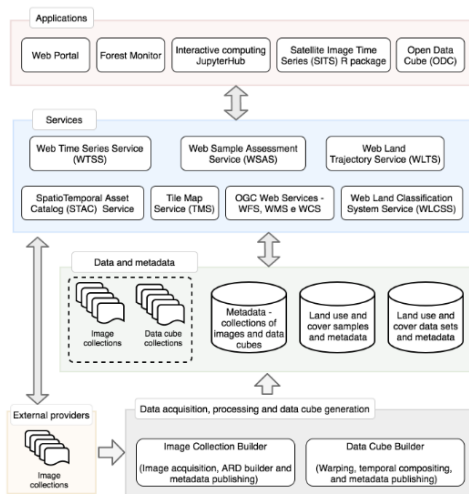
Computing platforms

Brazil Data Cube

- ▶ Production, visualization and analysis of large volumes of remote sensing images modeled as multidimensional data cubes for the entire Brazilian territory.
- ▶ Funded by FUNCATE.
- ▶ Executed by INPE.

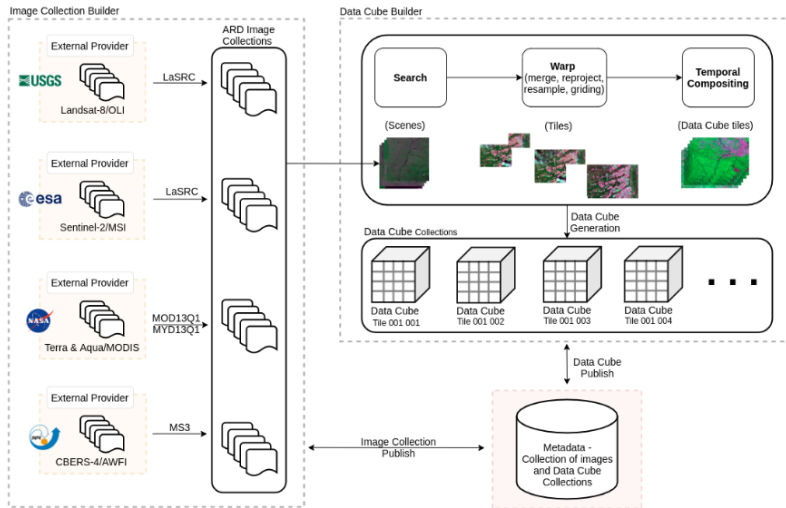


BDC architecture



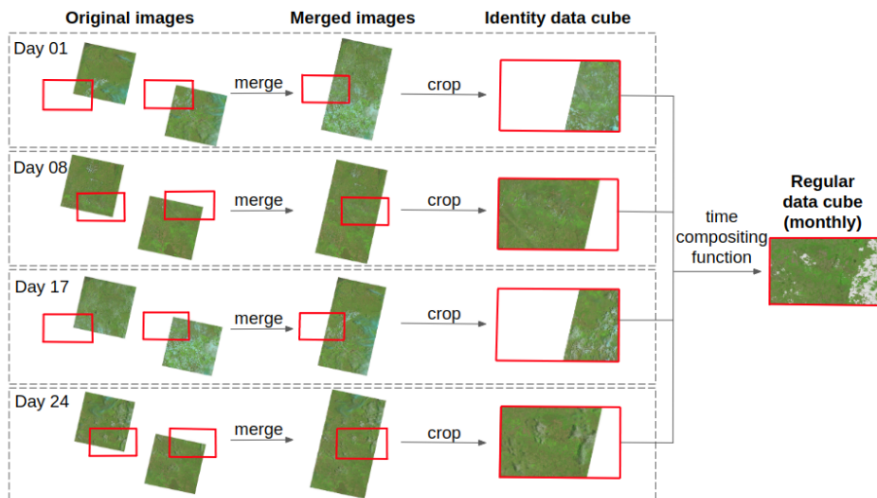
Brazil Data Cube architecture. Source [Ferreira et al., 2020].

BDC Analysis Ready Data



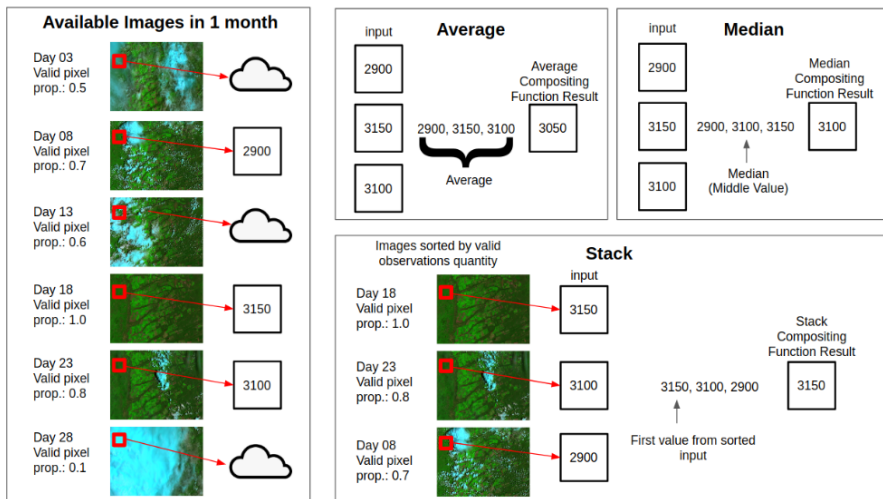
Processing of Analysis Ready Data. Source [Ferreira et al., 2020]

BDC cube regularization



Imagery regularization into cubes. Source [Ferreira et al., 2020]

BDC cube composition



Cube composition (cloud removal). Source [Ferreira et al., 2020]

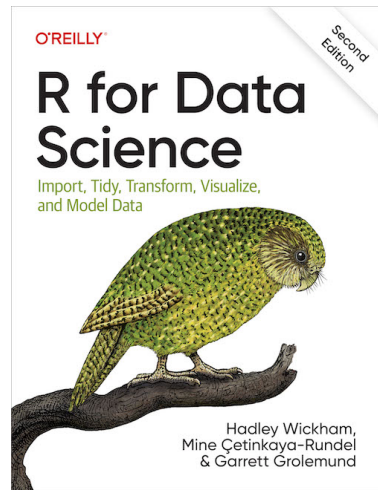
Programming languages

The *R* language

- ▶ *R* language is a free software environment for statistical computing and graphics.

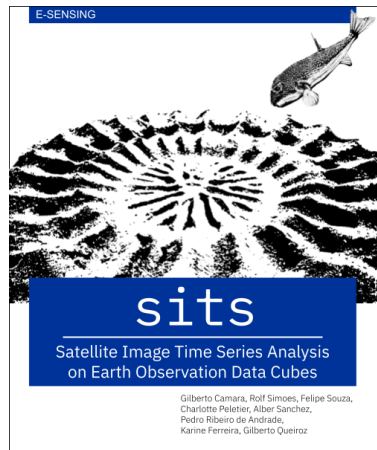


- ▶ *Data science is an exciting discipline that allows you to transform raw data into understanding, insight, and knowledge [Wickham et al., 2023].*

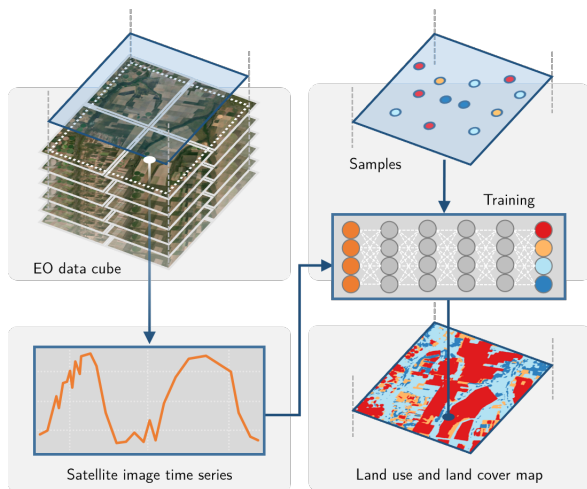


The *sits* package

- ▶ *sits* stands for Satellite Image Time Series.
- ▶ *sits* is an open-source *R* package for land use and land cover classification of big Earth observation data using satellite image time series [Gilberto Camara et al., 2023].

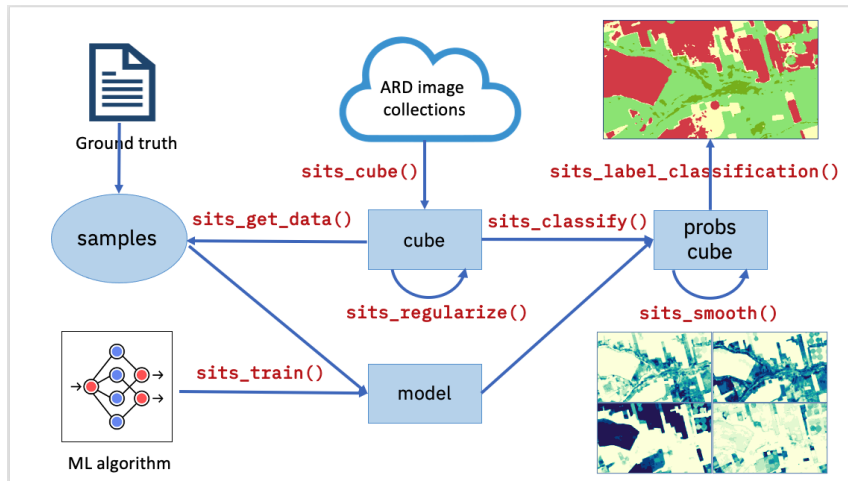


sits overview



Source [Gilberto Camara et al., 2023].

sits main functions

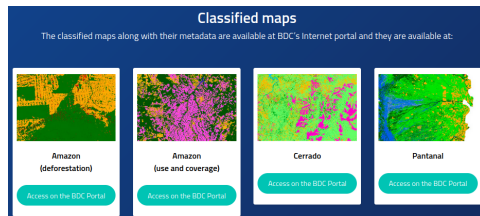


Source [Gilberto Camara et al., 2023].

Classifications of BDC Data Cubes

BDC Classifications

- ▶ Exploratory LULC maps of Brazilian Biomes.
- ▶ Using R & sits.
- ▶ Available online:
<https://data.inpe.br/bdc/web/en/land-use-and-land-cover-classification/>



BDC Classification code




- ▶ R packages with code and samples, available online:
<https://github.com/brazil-data-cube/bdcclassifications>



Conclusions

- ▶ Classification of time series of Remote Sensing imagery is an alternative to traditional way to produce Land Use Land Cover Change (LULCC) maps. These maps are required for solving Brazil's current crossroad between food production and environment conservation.
- ▶ Open Source data and tools such as Brazil Data Cube and the *sits* package reduce the barriers to newcomers to LULCC knowledge field.
- ▶ Exploratory LULCC maps of the Brazilian biomes are available along with the platform, tools, and data required for their improvement.

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