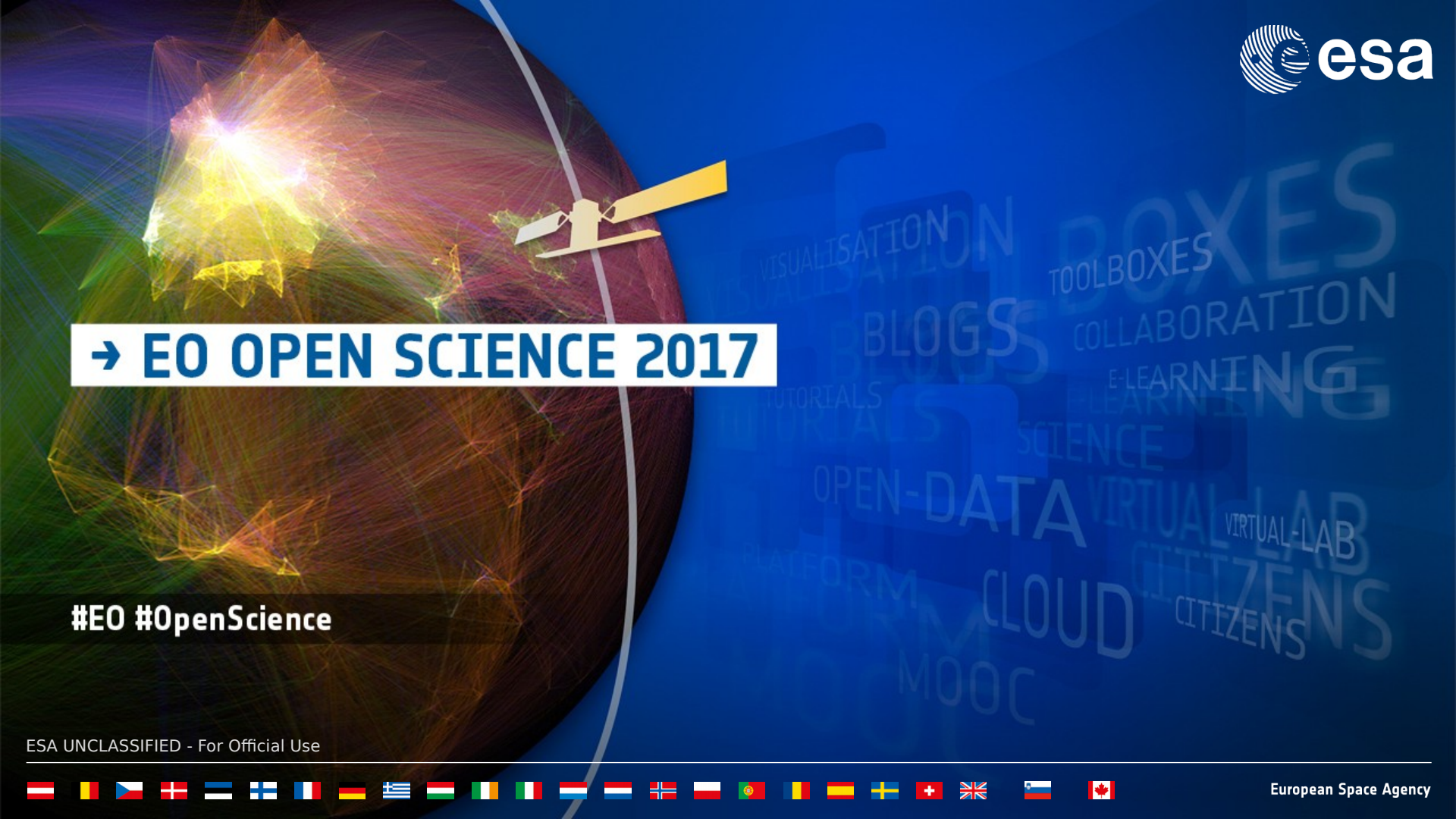


ESA UNCLASSIFIED - For Official Use

dtwSat

An R Package for Land Cover Classification Using Satellite Image Time Series

Victor Maus
International Institute for Applied Systems Analysis, IIASA
Laxenburg, Austria

27 September 2017

ESA UNCLASSIFIED - For Official Use

Open-source software for satellite image time series analysis

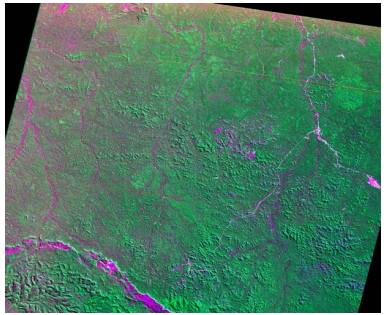
Available from the Comprehensive R Archive Network (CRAN)
https://cran.r-project.org/web/packages/dtwSat/index.html

```
> install.packages("dtwSat")
```

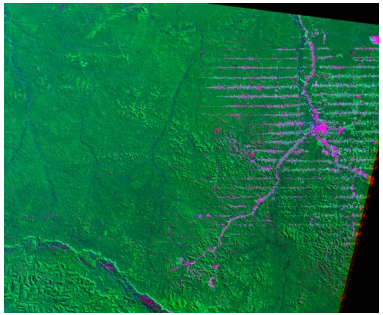
Development version on GitHub
https://github.com/vwmaus/dtwSat/

Data availability

1975



1986



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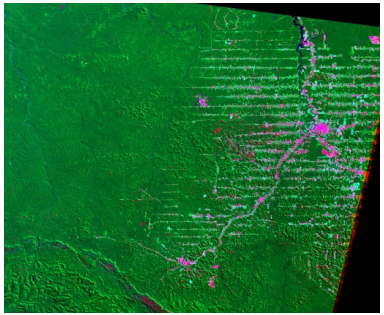
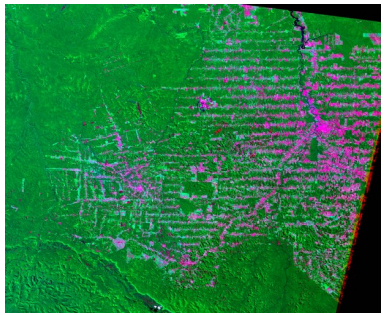
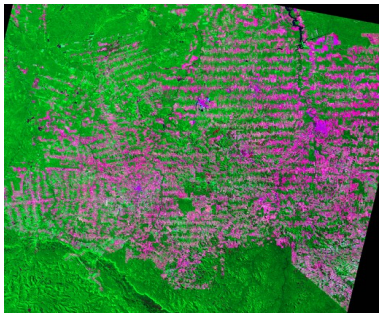


2001



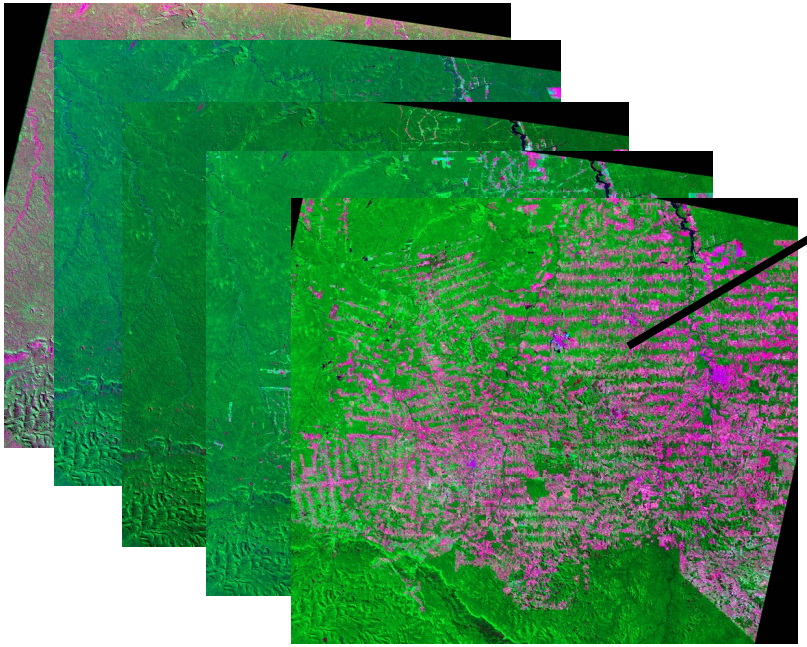
2013

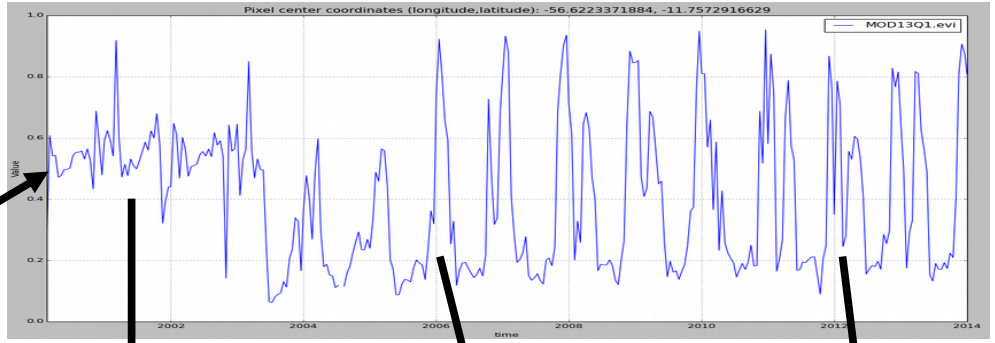


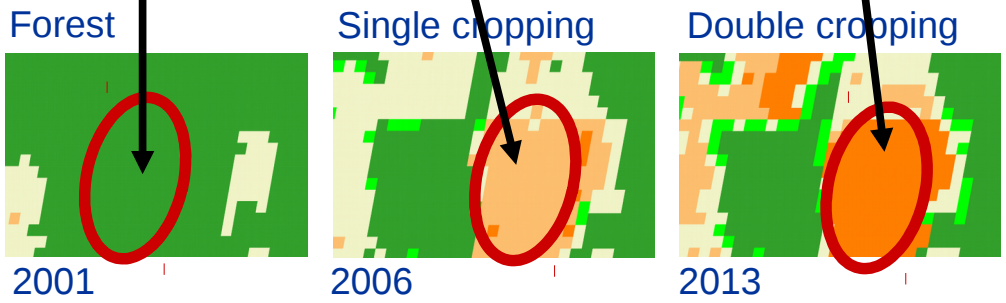
Rondônia, Brazil

Images souce: http://earthshots.usgs.gov/earthshots/node/39#ad-image-4

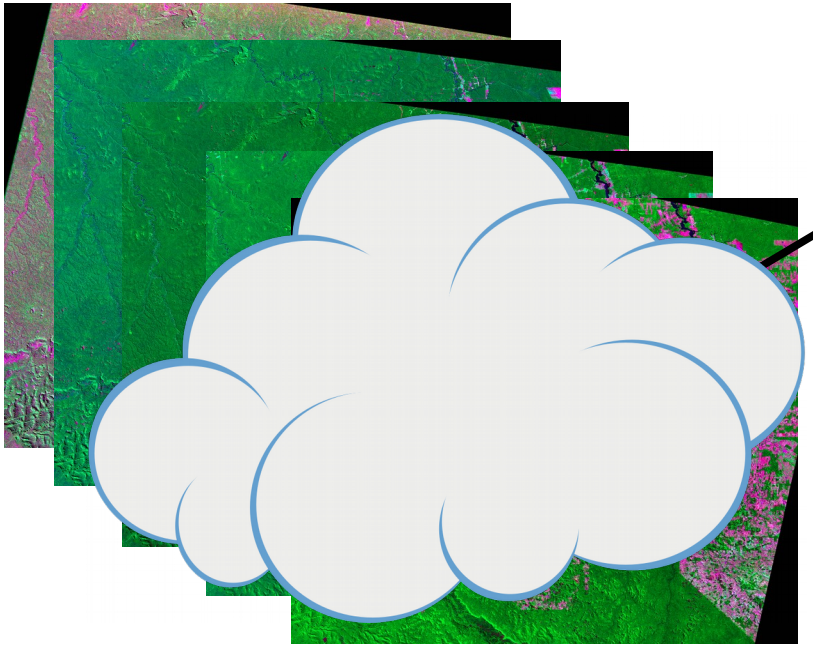
Satellite Image Time Series

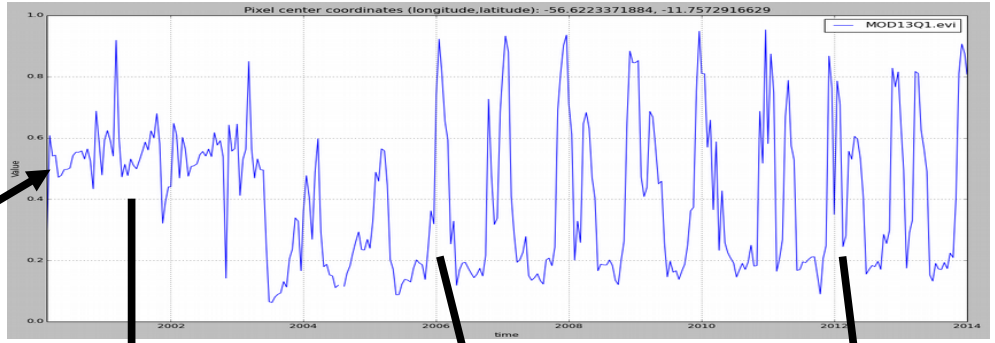




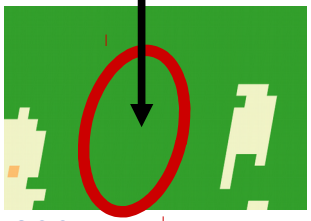


Satellite Image Time Series



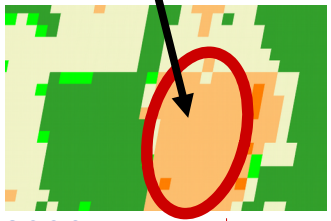


Forest



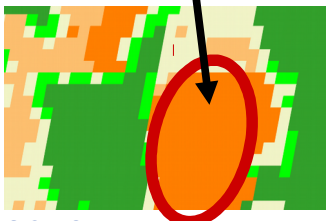
2001

Single cropping



2006

Double cropping

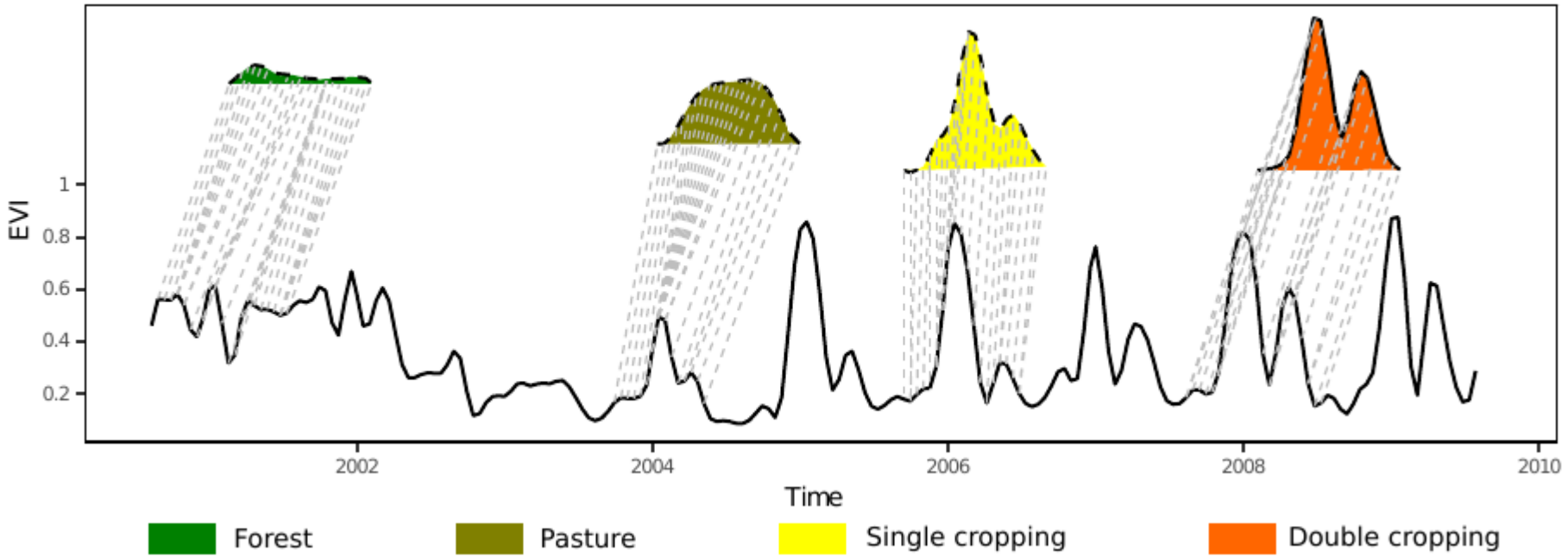


2013

Usually satellite time series are irregularly sampled, noisy, and out-of-phase.

Dynamic Time Warping (DTW)

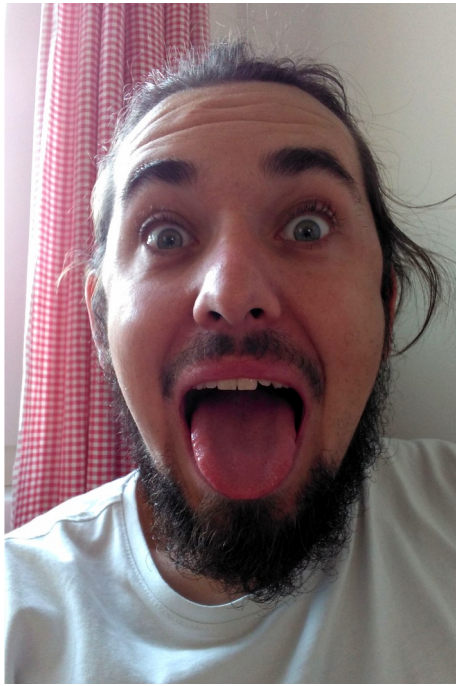
A good match needs shape similarity and temporal coherence



Time-Weight Dynamic Time Warping (TWDTW) method Maus et al., (2016)

Measuring similarity

Sandstone sculpture in the old Laxenburg train station, Austria.
St. Mark's Lion is the symbol of the city of Venice.



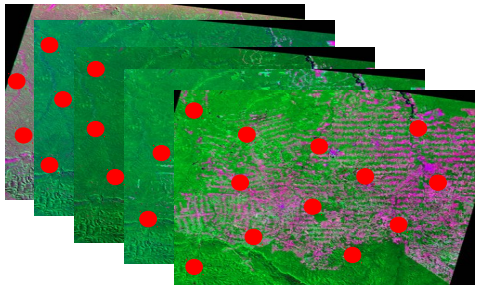
Unknown

How does dtwSat work?

INPUT

1. Satellite Time Series

2. Ground truth samples

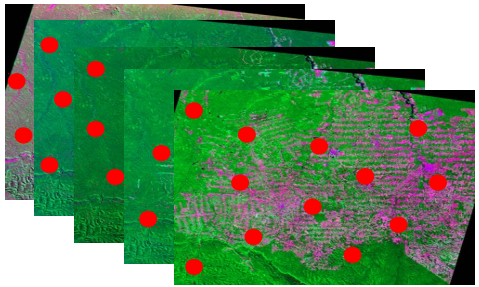


How does dtwSat work?

INPUT

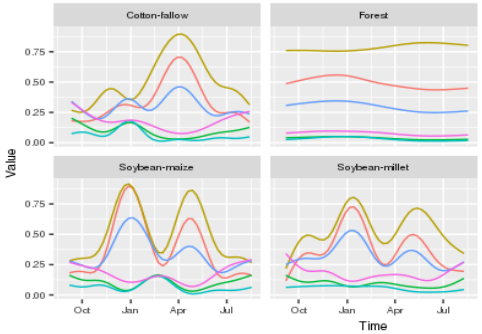
1. Satellite Time Series

2. Ground truth samples



GAM

Temporal patterns

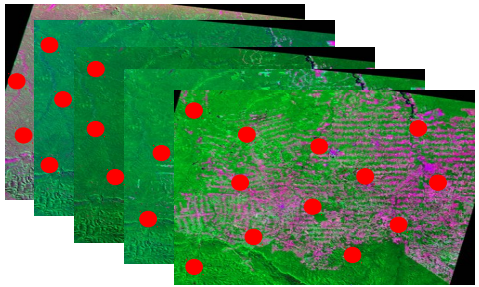


How does dtwSat work?

INPUT

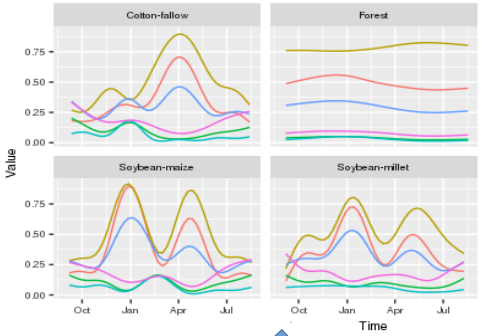
1. Satellite Time Series

2. Ground truth samples

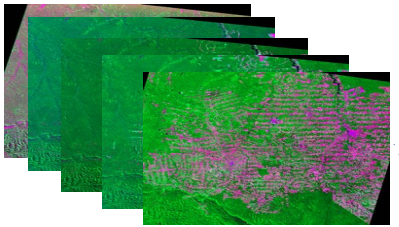


GAM

Temporal patterns

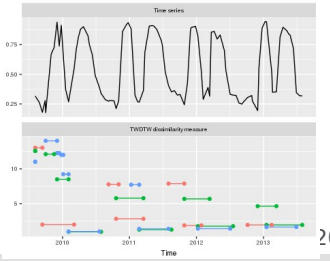


Raster stack



TWDTW

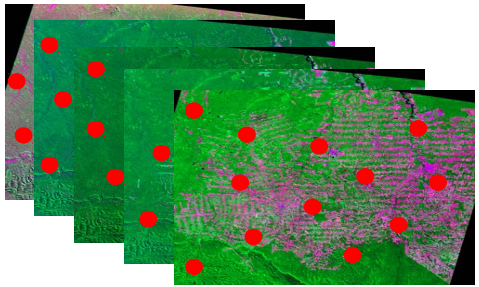
TWDTW alignments



How does dtwSat work?

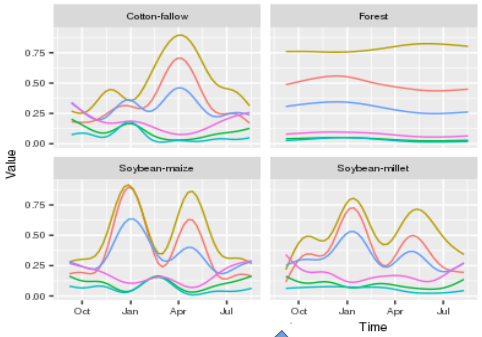
INPUT

1. Satellite Time Series
2. Ground truth samples

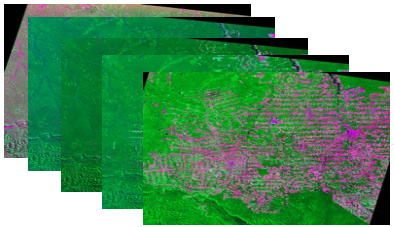


GAM

Temporal patterns

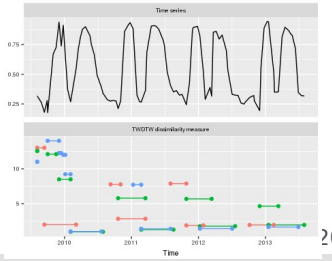


Raster stack



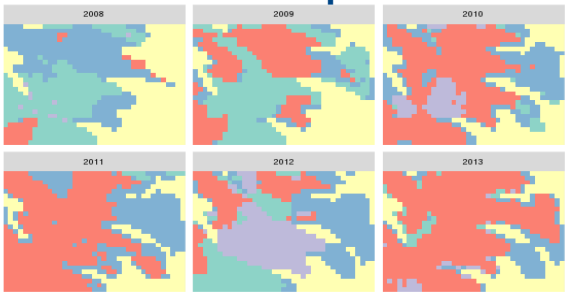
TWDTW

TWDTW alignments

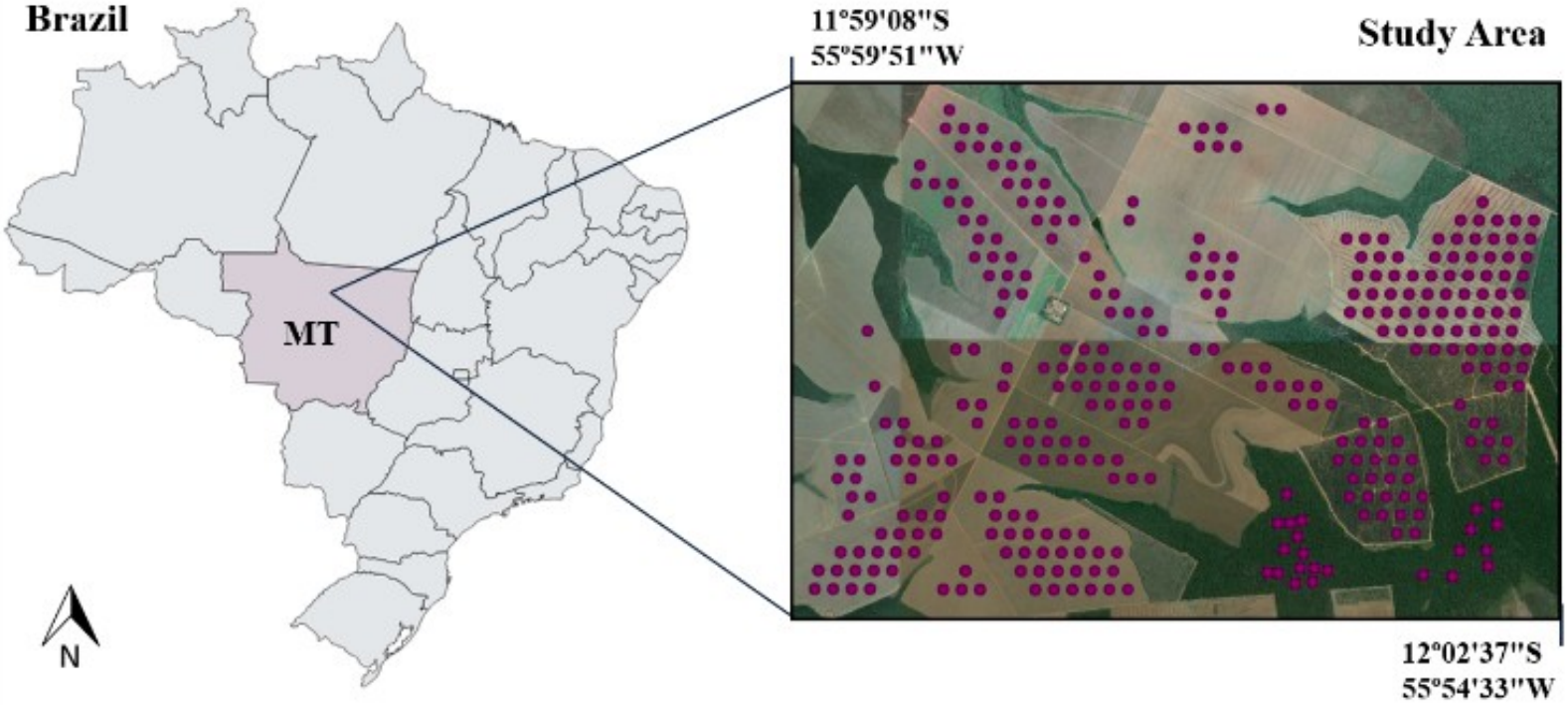


OUTPUT

Time series of maps



Demo – Study area

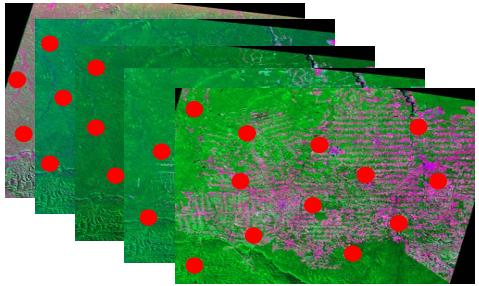


Demo – Input data

INPUT

1. MODIS MOD13Q1 Time Series
Bands: blue, red, nir, mir, evi, ndvi

2. Ground truth samples

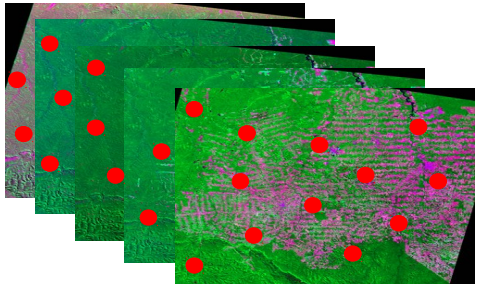


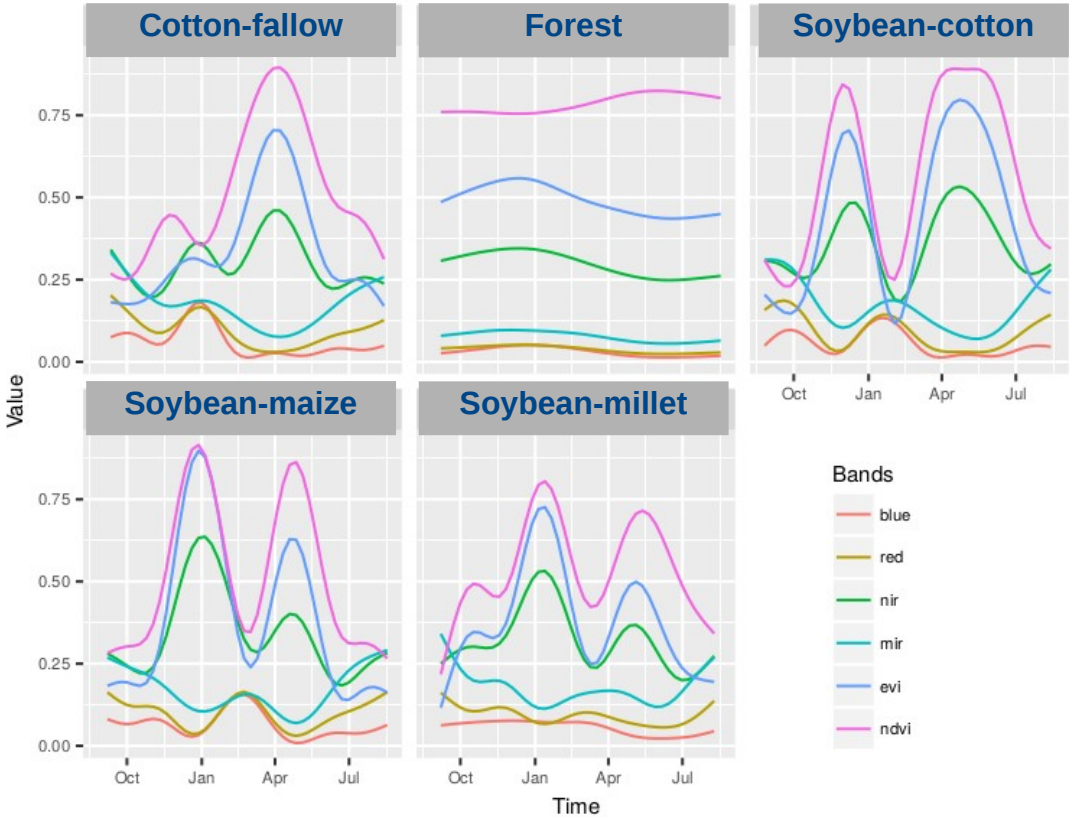
Demo – Temporal patterns

INPUT

1. MODIS MOD13Q1 Time Series
Bands: blue, red, nir, mir, evi, ndvi

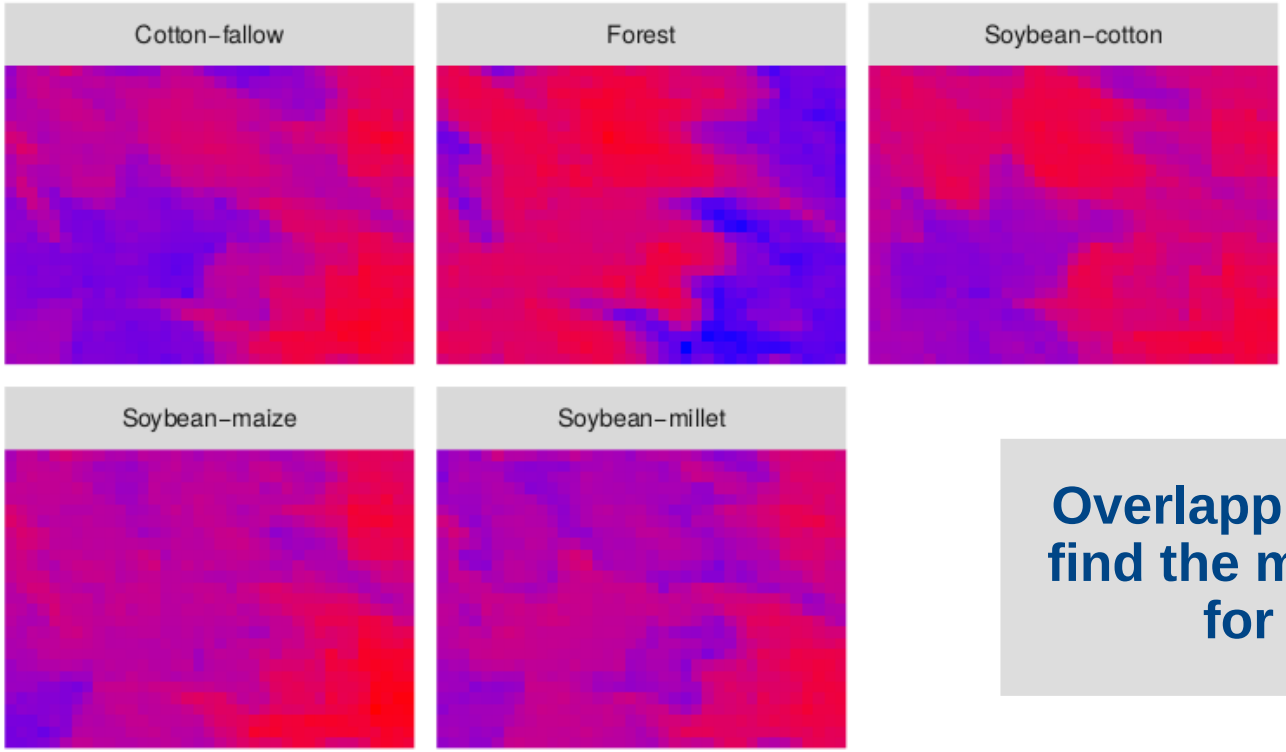
2. Ground truth samples

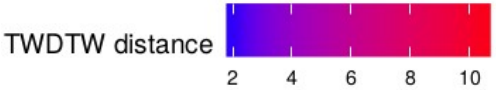




Demo – TWDTW results

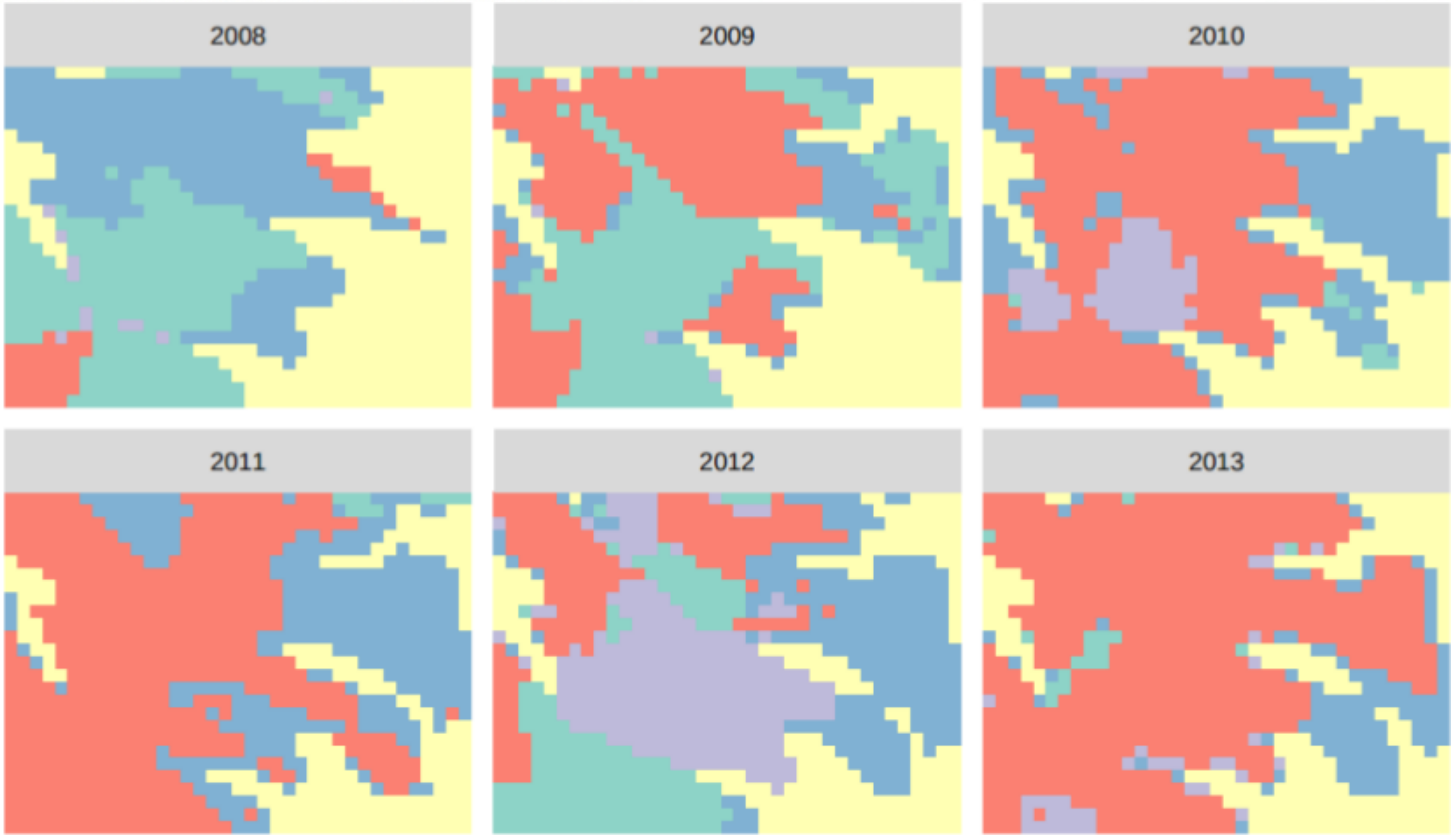
2008





Overlapping the layers we find the most similar class for each pixel.

Demo - Classification



MODIS

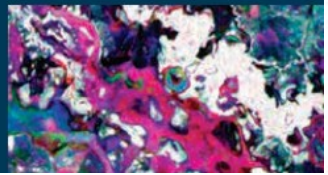
- Cotton-fallow
- Forest
- Soybean-cotton
- Soybean-maize
- Soybean-millet
- unclassified

Error assessment

Food and Agriculture Organization of the United Nations

Map Accuracy Assessment and Area Estimation

A Practical Guide



Contents lists available at ScienceDirect

Remote Sensing of Environment

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

Review

Good practices for estimating area and assessing accuracy of land change

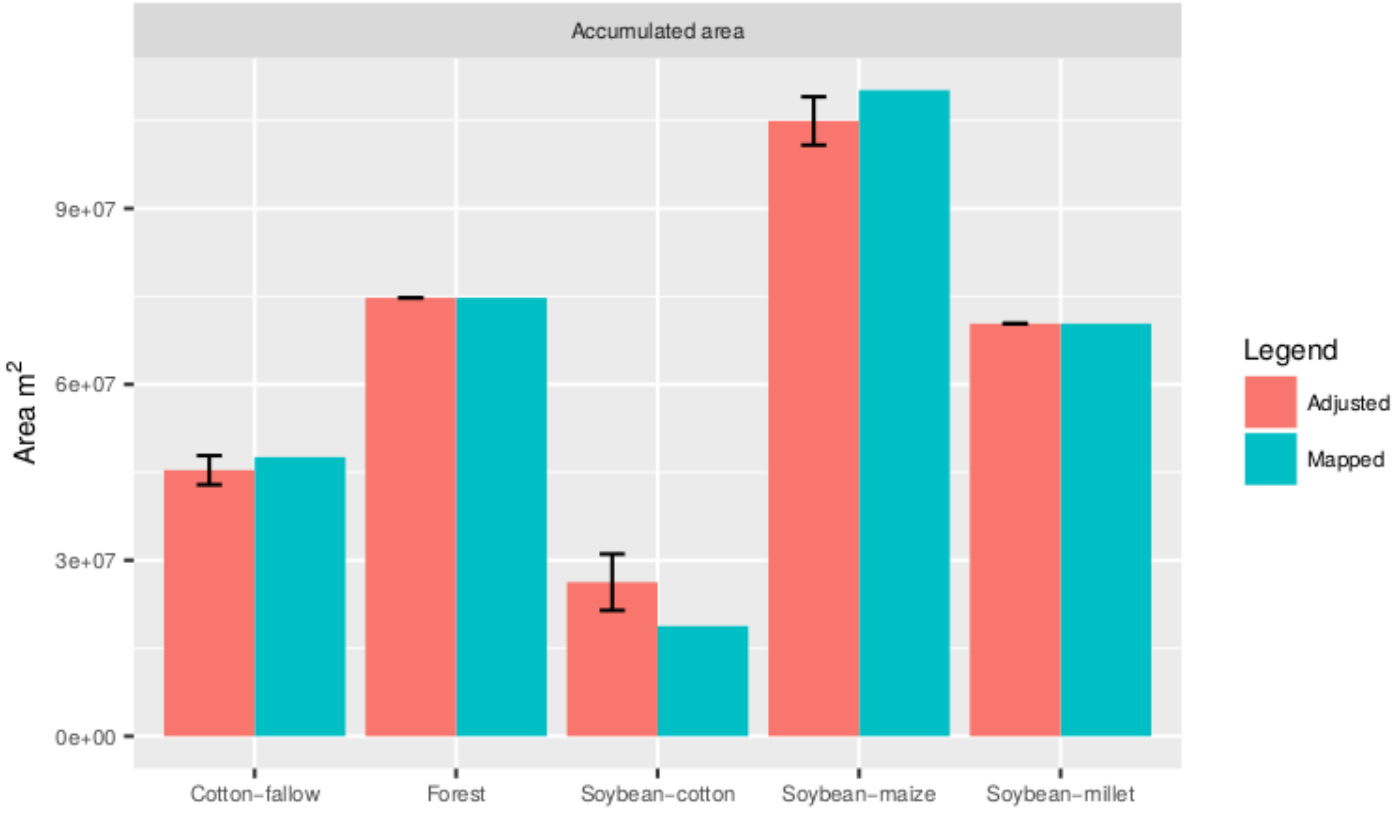
Pontus Olofsson [a,*], Giles M. Foody [b], Martin Herold [c], Stephen V. Stehman [d], Curtis E. Woodcock [a], Michael A. Wulder [e]

Error assessment

	Reference class								
Map class	Cotton-fallow	Forest	Soybean-cotton	Soybean-maize	Soybean-millet	Total	User's*	Producers's*	Overall*
Cotton-fallow	0.14	0.00	0.00	0.00	0.00	0.14	0.95±0.05	1.00±0.00	0.98±0.01
Forest	0.00	0.23	0.00	0.00	0.00	0.23	1.00±0.00	1.00±0.00	
Soybean-cotton	0.01	0.00	0.06	0.02	0.00	0.08	1.00±0.00	0.72±0.13	
Soybean-maize	0.00	0.00	0.00	0.33	0.00	0.33	0.95±0.04	1.00±0.00	
Soybean-millet	0.00	0.00	0.00	0.00	0.22	0.22	1.00±0.00	1.00±0.00	
Total	0.15	0.23	0.06	0.34	0.22	1.00			

Table 3: Accuracy and error matrix in proportion of area of the classified map. * 95% confidence interval.

Uncertainty area



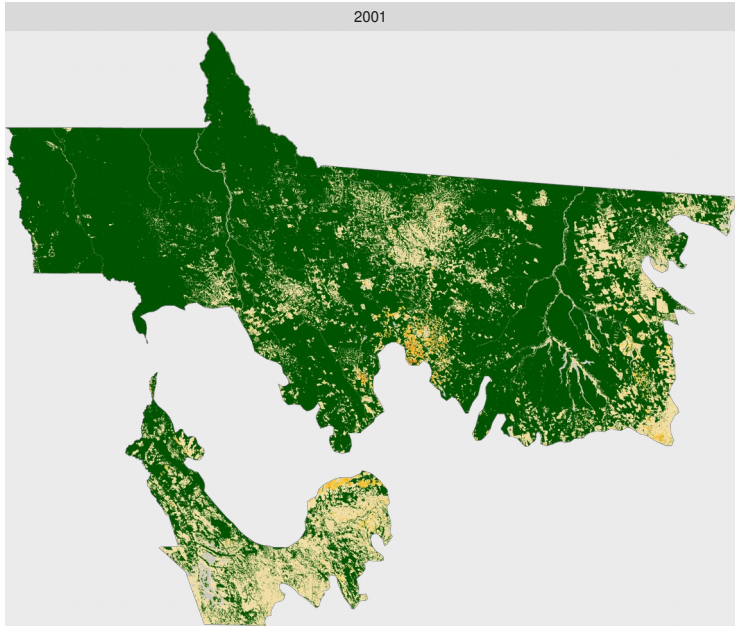
Journal of Statistical Software

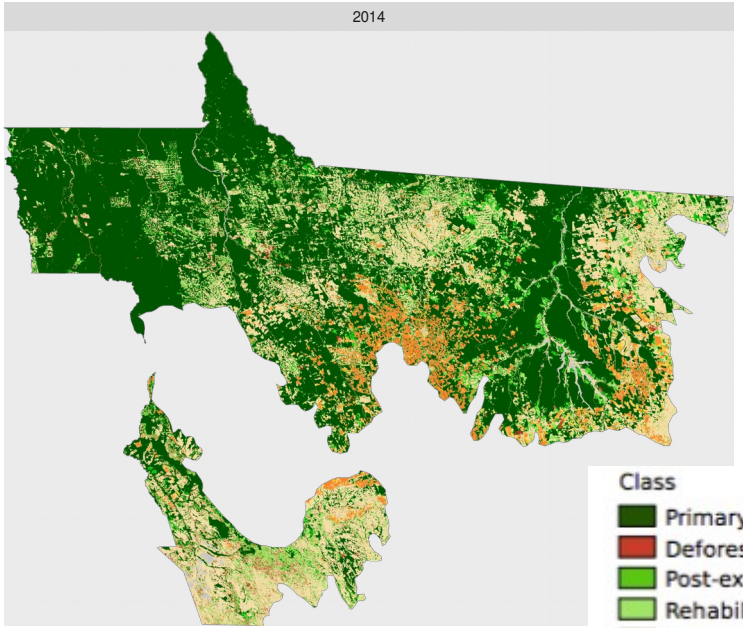
MMMMMM YYYY, Volume VV, Issue II. *doi: 10.18637/jss.v000.i00*

dtwSat: Time-Weighted Dynamic Time Warping for satellite image time series analysis in R

Victor Maus INPE
Gilberto Câmara INPE
Marius Appel University of Münster
Edzer Pebesma University of Münster

Larger area – Mato Grosso, Brazil





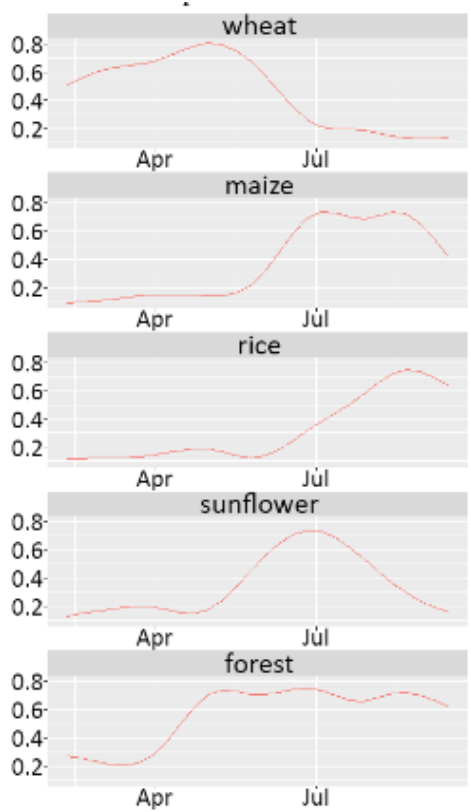
Class
- Primary forest
- Deforestation/Forest degradation
- Post-extraction/fire secondary forest
- Rehabilitated secondary forest
- Pasture
- Cotton
- Soybean
- Soybean-cotton
- Soybean-maize
- Unclassified

OA (%) = 80 - Using TWDTW distance to select the most similar class.

OA (%) = 91 - Using TWDTW distances as input to a SVM model.

e-sensing Project, INPE, Brazil, http://www.esensing.org/

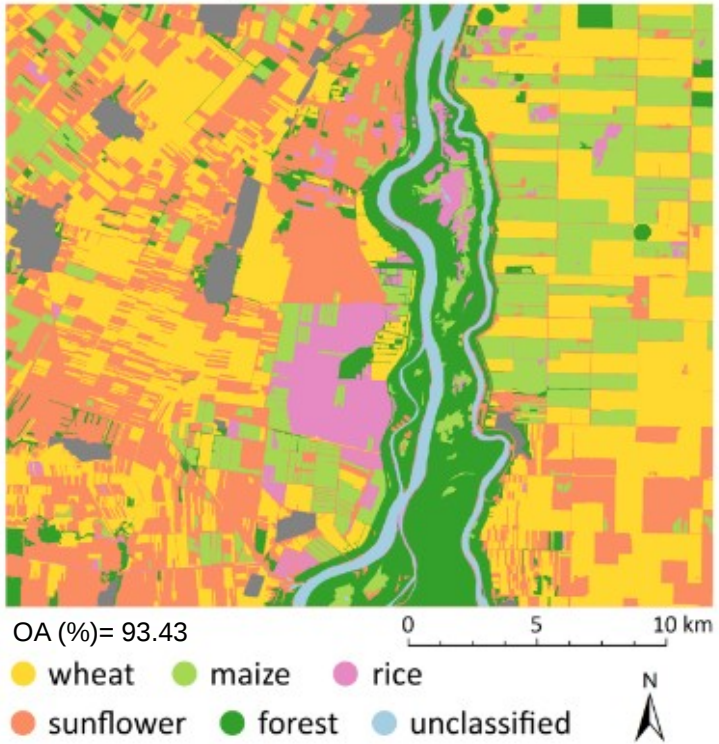
Other studies



Combining TWDTW with object based using Sentinel-2 NDVI time series in Romania.

Open source tools can speed up the development of new approaches.

Figure 4: Object-based TWDTW classification of the study area. The settlements (gray color) are masked.



Csillik, O. and Belgiu, M. (2017). Cropland mapping from Sentinel-2 time series data using object-based image analysis.

Thank you!

Victor Maus, maus@iiasa.ac.at

dtwSat on CRAN https://cran.r-project.org/web/packages/dtwSat/index.html

dtwSat development on GitHub https://github.com/vwmaus/dtwSat/

27 September 2017