Monitoring Brazilian Low-Carbon Agriculture Plan: The potential of satellite time series to detect adoption of selected agricultural practices

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Introduction

In 2009, the Brazilian Government presented the Low-Carbon Agriculture Plan (ABC Plan) to the world. It aims at to promote adoption of good management practices by farmers and ranchers nationwide. The selected practices included zero-tillage and integrated crop-livestock systems (also known as mixed farming systems) for cereal grains and beef or dairy production. However, the lack of monitoring procedures to evaluate the implementation and communication to policy makers and society in general may limit governance of the Plan ABC. This paper aims at analyzing the spectro-temporal behavior of integrated crop-livestock systems (ICLS) compared to a neighboring native Cerrado forest and a continuous degraded pasture

Material and Methods

The study area was the Capivara farm of the Embrapa Rice and Beans in the central region of Brazil (Figure 1).

Characteristics of the region:

-Two climate seasons (dry season from April to October and rainy season from November to October);

-Yarly rainfall: 1505mm;

-06 Paddocks + 04 areas under pivot used for the study ranged from 5.3 to 13.1 ha;

Fields sampled including crop rotations were:

- Forest,
- Continuous slightly degraded pasture (D Brachiaria),
- Soybean,
- Well-Managed Brachiaria Pasture (WM Brachiaria),
- Brachiaria+Maize,
- Rice

Figure 1: The study area located in the State of Goias, Brazil.

Eighty-three NDVI images of Landsat-8 OLI and Landsat-7 ETM+ sensors were combined to achieve annual coverage of cloud-free images of the summer growing seasons. Between 2009-2012 ETM+ was used while between 2013-2016 we selected OLI images. Figure 2 shows the series of methods applied in the study.

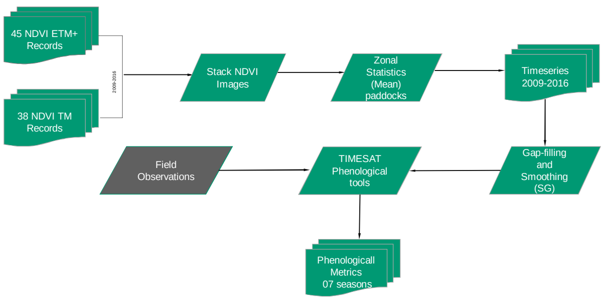

Figure 2: Flow chart of the sequences of methods used in the study.

Results

Gap-filling and smoothing NDVI profiles, such as phenological metrics extracted from NDVI profiles were made using TIMESAT software 3.2 version (Eklundh and Jönsson, 2011) (web.nateko.lu.se/timesat/).

Smoothing and Gap Filling

Gap-filling and smoothing methods based on Savitsky-Golay were used for noise removal in order to derive phenological metrics from the time series (Figure 3).

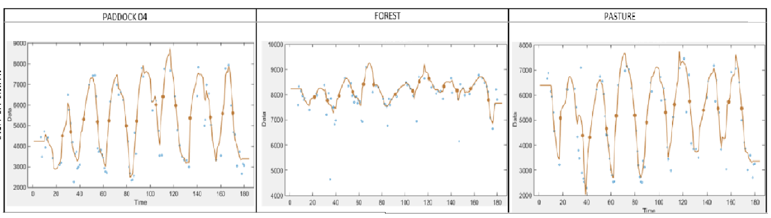

Figure 3: Smoothed and gap-filled NDVI profiles of three land use classes (annual crop, forest and pasture) using Savitsky-Golay method based on a TIMESAT output (SOS/EOS = 0%; N° Interactions= 0,4). Blue dots mean Landsat satellite observation and the red lines are processed NDVI profiles. ,

Phenological metrics

Four phenological metrics were extracted for each acquisition year (2009-2016). Average metrics per class indicate that length, peak and amplitude NDVI values of the growing period are likely to be good metrics based on visual evaluation (Figure 4).

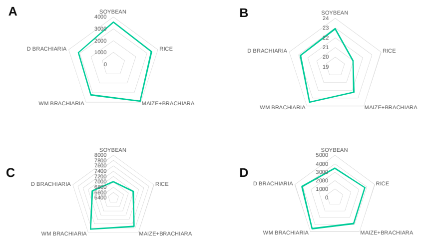

Figure 4: Radar chart showing the phenological metrics of the different crop classes: A- NDVI base value (x1000); B-Length of the cropping season (days); C- NDVI peak value (x1000); D- NDVI amplitude (x1000).

Throughout the years, distribution of phenological metrics of all profiles varied depending on the type of land use. One can observe that the base value was the highest and amplitude value was the lowest in the forest class (Figure 5). WM Brachiaria, D Brachiaria and Forest classes can somehow be identified using the phenological metrics, but further studies should be conducted on larger areas combining different satellites.

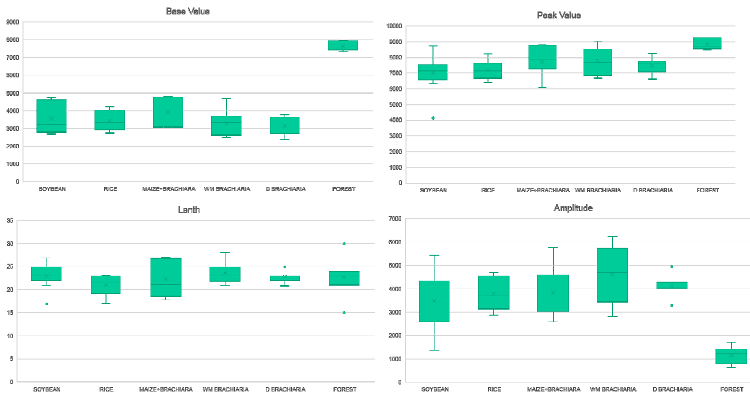

Figure 5: Box and whisker plots of the phenological metrics in different land use and management. The middle horizontal line is the median value, the extent of the upper box is the first quartile, the extent of the lower box is the third quartile, and 50% of the data lie within the 2 boxes (the interquartile range). The extent of the whiskers is the last data point or 1.5 times the distance of the interquartile range if there are outliers. Outliers are marked with dots in the plot.

Conclusions

- The gap-filling and smoothing procedures are necessary pre-processing steps of the time series, especially in areas with high cloud cover frequency.
- Phenological metrics, such as length, peak and amplitude values showed high potential to be used to discriminate land uses;
- The findings of this study are somewhat biased because of the limited frequency of the satellite image acquisition. The theoretical 16-day revisit of landsat satellite is generally not reached because of cloud conditions. However with the recent Sentinel-2 ESA satellite, with a 5-day revisit expected by the end of 2017 for Brazil, the discrimination of the land use classes using phenometrics should largely gain in accuracy.

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