MODIS TIME SERIES TO ASSESS PASTURE LAND

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1. INTRODUCTION

An increase of 76% in the cultivated sugarcane area was observed in South-Central Brazil (http://www.dsr.inpe.br/canasat) during the last three crop years. Future expansion of sugarcane cultivation in Brazil is currently regulated by an Agroecological Zoning of Sugarcane, that establishes favorable land for sugarcane production based on climate and environmental restrictions [1]. This zoning classified 64.7 million hectares as being suitable for sugarcane expansion. Fifty seven percent of this area was pasture land in 2002 [2] and mainly concentrated in Mato Grosso do Sul state, Brazil [1]. Studies have shown that most of the recent sugarcane expansion has occurred on pasture land [3,4]. Moreover, this expansion was concentrated on traditional pasture land of extensive cattle farming. Improved technology in cattle production made it possible to reduce pasture land without herd reduction and consequent increase of available land for agricultural crops [5]. In case this pasture land is degradated the benefit of biofuel production from sugarcane is even higher. However, to determine the level of pasture land degradation, from remote sensing images, is not a trivial task and will require intensive fieldwork.

Changes in spectral parameters such as vegetation indices [6] and linear spectral mixing model [7] of MODIS time series can represent biophysical conditions of pasture land that can be related to different levels of degradation [8]. Under these assumptions this work has the objective to use time series of vegetation indices and fraction images derived from MODIS data to distinguish pasture from other classes of Cerrado (Brazilian savanna) and assess different levels of pasture degradation in Mato Grosso do Sul state, Brazil.

2. MATERIALS AND METHODS

A field campaign was carried out in May 2009 in order to acquire several information from specific points of pasture land and native vegetation in the municipalities of Corguinho, Rio Negro and Camapuã in Mato Grosso do Sul state, Brazil (Fig. 1c). Three classes of vegetation were identified (Fig. 1c), according to the classification of [9], i.e., Pasture - native and anthropic (*Ap*, 233 points), Savanna and its subclasses (*Sa*, 57 points) and Semideciduous Alluvial Forest (*Fa*, 46 points). The last two classes were grouped into a single class called *Other* in this work. The pasture class was grouped into three classes according to its condition, i.e., good pasture land

(*Ap1*, 84 points), pasture with invasive plants (*Ap2*; 127 points) and pasture with bare soil exposure and termite mounds (*Ap3*; 22 points).

The MODIS products MOD09 (bands 1, 2, 3 and 6), 8 days composition, tile H12V10, from February 2000 to August 2009 were used to generate Normalized Difference Vegetation Index - NDVI [10], Normalized Difference Water Index - NDWI [11], and vegetation and soil fractions [7] for each visited field point. The same endmembers were used to obtain the fraction images for the whole data set. The NDVI is correlated with the vigor of the plant and NDWI relates to the water content in leaves and both are useful to indicate the quality of the pasture land over time [8]. The fraction images allow identifying the proportion or contribution of each endmember in the pixel value and its variation over time is related seasonal changes and land use and cover.

In order to reduce noise in the time series of images, without affecting the seasonal change of the vegetation [12], the wavelets technique was applied at various levels of decomposition from which the most appropriate level was selected to represent the time data profile (Fig. 1b). The last year of the filtered time series was the base to extract the input parameters in the WEKA J48 classifier (http://www.cs.waikato.ac.nz/ml/weka), first to distinguish between *Pasture* and *Other* and second to distinguish among *Ap1*, *Ap2* and *Ap3* classes. The parameters used were: maximum and minimum value of the curve, amplitude, area under the curve (Fig. 1d) and the difference between the areas under the vegetation and soil fractions curves (Fig. 1a). This parameter indicates the relationship between the proportions of vegetation and soil and can indicate the degradation, either by the exposure of bare soil or by the presence of invasive plants.

3. RESULTS AND DISCUTION

The decomposition levels three (N3) and four (N4) were the best to represent, respectively, the intra- and inter-seasonal temporal variability of the data, (Fig. 1b). The resulting curves allowed to extract the parameters used to classify and to define the dry and wet seasons that are evident in the TM/Landsat images (3B4R5G; Fig. 1b). The combined analysis of vegetation fraction and soil fraction time series showed the conversion of savanna to pasture, which occurred between 2007 and 2008. This conversion is also illustrated in the TM/Landsat images acquired during that period (3B4R5G; Fig. 1a).

The two levels of decomposition (N3 and N4) performed equal with an 84.5% of correctly classified pixel for the *Ap* class. For the *Other* class the N4 level performed slightly better than the N3 level (Tab.1). However, best results were obtained with the N3 level to classify *Ap1* and *Ap2*. The *Ap3* class was mainly misclassified as *Ap1* for both levels (Tab.1).

The N3 and N4 levels distinguished well between *Ap* and *Other*, which can be attributed to some evident differences in the floristic composition of in these classes. Level N3 distinguished better among pasture classes than level N4 since it was able to enhance subtle variations among the classes during the analyzed period. The low performance of both levels to classify *Ap3* and its confusion with *Ap1* is likely to be related to the moderate spatial resolution of the MODIS pixel (250 m) that is predominantly dominated by vegetation and not by minor bare soil patches and some termites mounds that characterize the *Ap3* class.

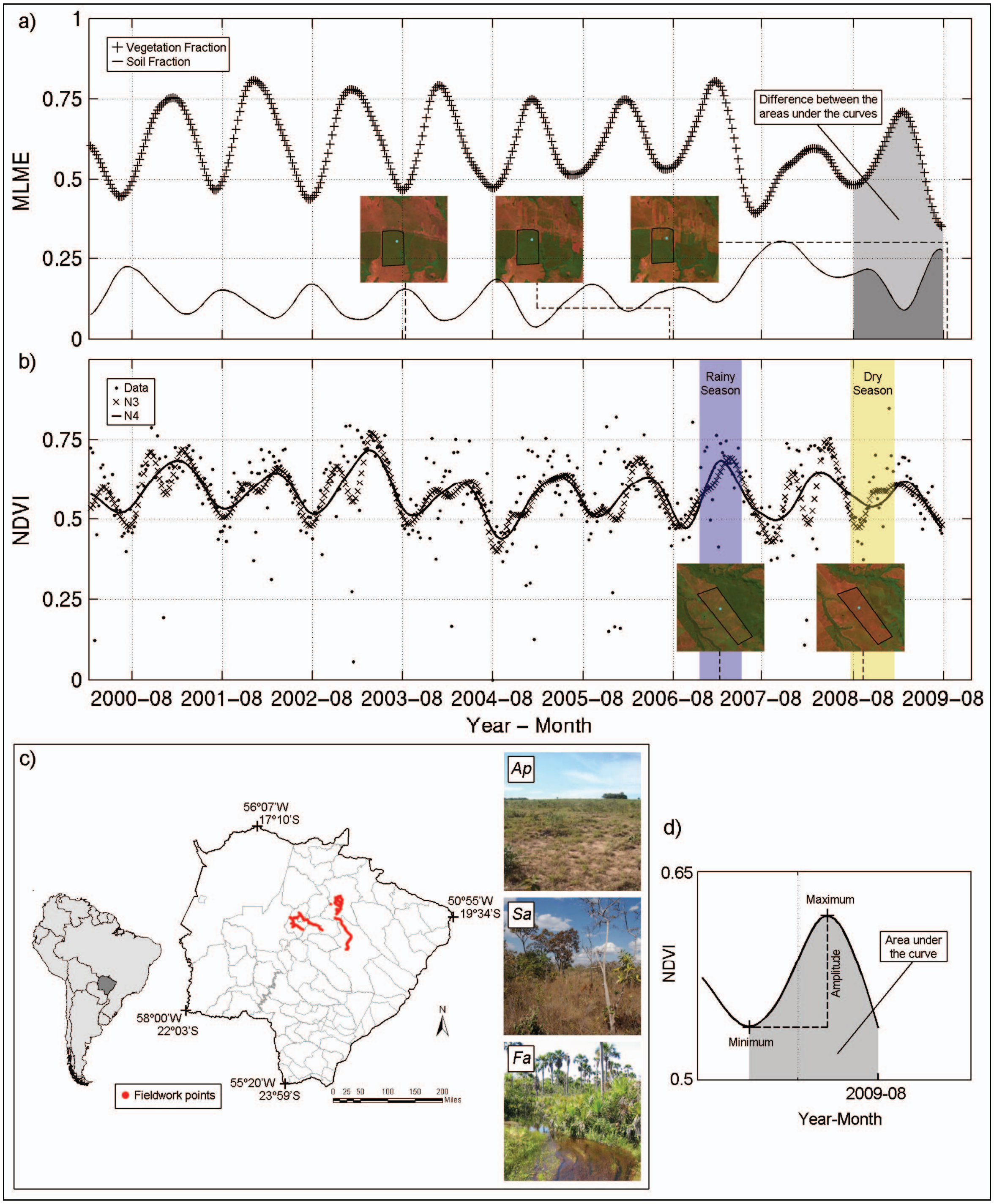

Figure 1. Time series of vegetation and soil fractions (1a); Time series of NDVI, decomposition levels (N3 and N4) and, a highlight of dry and wet seasons (1b); study area and vegetation classes (1c); parameters used for the classification (1d and 1a).

Table 1. Percentage of correctly classified pixels using two levels of decomposition.

Decompositions (Wavelets)	Correctness per class (%)				
	Ap	***Others***	***Ap1***	***Ap2***	***Ap3***
Level 3	84.5	55.3	52.4	69.6	0.05
Level 4	84.5	60.2	46.3	61.6	0.15

4. FINAL CONSIDERATIONS

The wavelet technique applied to a time series of MODIS images allowed to obtain parameters that were used to classify differences in pasture land. Pasture land was distinguished from Cerrado (others) and separated between good pasture land and pasture with invasive plants. Pasture land with bare soil patches and termite mounds were not distinguished from other classes of pasture. Pasture degradation is a dynamic process and in future analysis it is recommended to extract parameters from the whole time series to improve classification of degradated pasture land.

5. REFERENCES

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