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## Regional scale land use/land cover classification using temporal series of MODIS data at the High Taquari Basin, MS, Brazil

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**Abstract.** This paper describes a methodology for providing systematic land use/land cover classification on a regional scale, with specific application to the High Taquari Basin, in the state of Mato Grosso do Sul, Brazil. The methodology is based on previous work developed at INRIA by Bouzidi et al. (2000) and proposes the use of multitemporal 250m resolution surface reflectance data from the Moderate Resolution Imaging Spectroradiometer (MODIS), on board NASA's Terra satellite. This data will be coupled with higher-resolution training information in order to compute characteristic temporal MODIS reflectance profiles for each class and each band. A linear mixture model will then be applied so as to compute the proportions of each class within each MODIS pixel over areas where classification information may not be available, thus enabling the monitoring of land use/land cover over large regions such as the High Taquari Basin and its adjacencies.

**Key-words:** remote sensing, multitemporal image processing, land use/land cover classification, data fusion.

### 1. Introduction

It has already been widely recognized that land use and land cover (LULC) play a very important role on regional to global scales, with impacts over ecosystem functioning, ecosystem services, and biophysical and human variables such as climate and government policies (Meyer and Turner (1994)). However, even though LULC classification using high-resolution remotely sensed images has been shown to be quite successful over the last years, it has become clear that using this approach to assess large areas on a regular basis ends up yielding prohibitive computational and financial costs. As an alternative, several authors have proposed the exploitation of the rich temporal information contained in sequences of freely available coarse resolution satellite data (Holben and Shimabukuro (1993), Bouzidi et al. (2000), Meirelles et al. (2003)). Traditionally, many of these approaches have employed data from NOAA's AVHRR sensor (1.1km resolution), but nowadays data from NASA's MODIS sensor is also available, featuring better spatial resolution (up to 250m) and superior standards of calibration, georeferencing and atmospheric correction, as well as detailed per-pixel data quality information. As such, a number of researchers have started to apply this kind of data for land cover assessments (Strahler et al. (1999), Wessels et al. (2004)). In this paper, a

methodology for classifying LULC on a regional scale is proposed, with specific application to the *Cerrado* tropical savannah biome in mid-western Brazil.

## 2. Study Area

The High Taquari Basin is located in the state of Mato Grosso do Sul, Brazil, and comprehends a total area of 28.046 km<sup>2</sup> (Silva (2003)). The Taquari river itself is a very important tributary of the Paraná river, and plays an essential role within the Pantanal ecosystem. Unfortunately, the basin has been suffering a severe silting process over the last years due to uncontrolled land use expansion, and thus requires constant monitoring. Nevertheless, the surveillance of the entire basin corresponds to an expensive and complex effort, and it is thus not currently viable on an operational basis. Additionally, the basin has already been the subject of numerous studies (Bueno et al. (2003), Silva (2003), among others), and therefore it can be considered particularly suitable as a pilot area for research.

## 3. Materials and Methods

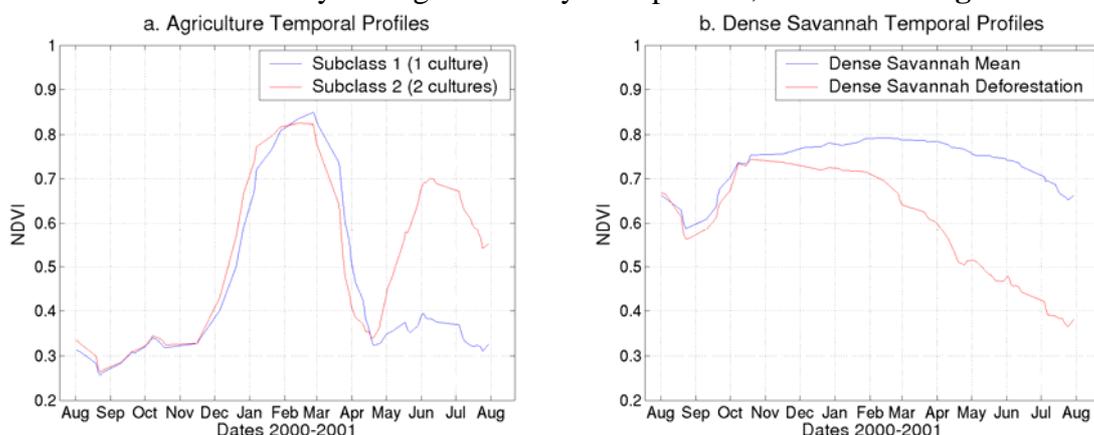
The methodology described here is based on previous research developed at INRIA for NOAA/AVHRR imagery (Bouzidi et al. (2000)). In order to perform this work, a detailed LULC classification for the entire High Taquari Basin was obtained for the year 2000, which was based on LANDSAT TM imagery from August 2000 and extensive field trips (Silva (2003)). Moreover, daily Terra/MODIS atmospherically corrected surface reflectance data were also acquired (red and near infra-red bands at 250m resolution and corresponding metadata), so as to cover a one year period from August 2000 to July 2001.

Once all data are available, the daily MODIS images and metadata are processed in order to select the best quality data and filter out areas contaminated by clouds, cirrus, shadow and high levels of aerosol. Additionally, it is also necessary to register the resulting MODIS image sequences to the available classification image for the year 2000. After that, a process of class merging and splitting must be performed on the original classification data, so as to define a set of meaningful classes that are effectively discernible with MODIS temporal reflectance information. At this point, the process of *temporal profile learning* can be performed. In order to do this, only areas where a MODIS pixel covers one single type of LULC class are selected (i.e., “pure pixels”). A mean reflectance value is then computed for each class and each band, and at each date of the temporal sequence. Additionally, the computed mean values may then be fitted to a pre-established profile model in order to minimize noise and increase profile interpretability. After that, the *regional scale sub-pixel classification* itself can be finally computed, using a linear mixture model in order to estimate the proportions of each class within each MODIS pixel. This model considers that the final observed reflectance  $R_i$  of a given pixel  $i$  is the result of a linear combination of the reflectances  $R_j$  of each class  $j$  (learned before) and their proportion  $\rho_{ij}$  within the pixel. As such, sub-pixel classification can then be estimated by computing the set of proportions that minimize the distance between the observed and modelled reflectances for each date and for each band.

## 4. Preliminary Results

At the moment of submission of this extended abstract, all MODIS data have been acquired, processed and registered to the classification image, and a set of 71 images were selected for the final temporal sequence. Temporal profiles based on pure pixels have then been computed and, after preliminary analysis, it appears that four major classes may be well distinguished: agriculture, savannah, pasture, and urban areas. Moreover, it has been found that distinct agriculture practices can also be identified, since the growth and senescence periods of each

crop are easily observable in the temporal profiles (**Figure 1a**). Finally, areas of deforestation were also found to be clearly distinguishable by their profiles, as shown in **Figure 1b**.



**Figure 1.** NDVI temporal profiles for **a)** agriculture types and **b)** dense savannah deforestation

## 5. Conclusions

Although still a work in progress, the intermediate results obtained so far have been considered to be satisfactory. As such, it is expected that MODIS data will indeed provide an affordable and effective way of monitoring the High Taquari Basin and its adjacencies, thus enabling researchers to more easily assess land use and land use change in the area over time, particularly in regard of the conversion of natural vegetation to agriculture and pasture use.

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