An On-line Visualization Tool Using MODIS and TRMM Time-series for Land Use and Land Cover Studies at South America

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Abstract. *This work presents the development of a tool for visualization of time-series derived from remote sensing sensors. This work introduces the new concept of Virtual Laboratory of Remote Sensing Time Series to support Land Use and Land Cover - LULC Changes studies over large spatial temporal datasets. The MODIS (Moderate Resolution Imaging Spectroradiometer) and TRMM (Tropical Rainforest Measuring Mission) time-series are used to support applications on the environmental monitoring as deforestation detection. The Virtual Laboratory of Remote Sensing Time Series is composed by a dataset with more than 500 million EVI2 (Enhanced Vegetation Index 2) profiles for the entire South America continent based on a 11 years history of daily MODIS data acquisition. The original EVI2 time series was filtered using the Daubechies (Db8) orthogonal Discrete Wavelets Transform. The filtering procedure smoothes high frequencies that are associated with clouds cover and sensor noises. The EVI2 time series were integrated into the virtual globe using Google Maps and Google Visualization Application Programming Interface functionalities. For each call of a geographic coordinate from the virtual globe the EVI2 profiles are instantaneously recovered for visualization. The tool demonstrated to be useful for rapid LULC change analysis to environmental monitoring, at the pixel level, over large regions.*

Keywords: *MODIS, remote sensing, time-series visualization, virtual globe.*

1. Introduction

Over the last few decades, multi-temporal images of Earth observation satellites have turned into a paramount source of information for monitoring the planet Earth, particularly to study the land use and land cover LULC changes [Defries et al. 2004]. The development of geobrowser tools, based on virtual globes, has provided free access to high spatial resolution images and geographical maps derived from remote sensing satellites. The development of these virtual globes allowed researchers and general public to visualize geospatial data, to understand multi-scale geography, to process data

and to publish information [Butler, 2006]. The visualization of long term remote sensing data sets for scientific purposes has great potential for better understanding the complex space-time dynamics of terrestrial ecosystems. However, the pre-processing and extraction of information from these data sets require specific software and advanced technical knowledge to put them available to the end-users in a friendly and accessible way. The integration of time series for studies on LULC changes using virtual globes such as Google Maps (http://maps.google.com/) Google Earth (http://earth.google.com/) and Microsoft Virtual Earth (http: / / www.microsoft.com/maps/) are not yet easily accessible to users due to constraints in data storage and the lack of a specific computational architecture for integration and visualization of this time-series. This work presents the development of a tool for instantaneous visualization of time-series derived from remote sensing sensors. This work introduces the new concept of Virtual Laboratory of Remote Sensing Time Series to support Land Use and Land Cover Changes studies over large spatial temporal datasets.

2. The Virtual Laboratory of Remote Sensing Time Series

The virtual laboratory of remote sensing time-series concept is proposed by [Freitas et al. 2011]. The macro framework of the Virtual Laboratory of Remote Sensing Time Series is divided into five components that are presented in Figure 1. The Dataset component includes the hardware and software structures to storage the remote sensing time series data. The Dataset manager establishes the connections among all the laboratory components. The Algorithm module and the Analysis module provide the basis for the time series analysis and visualization. The Visualization module establishes the interface between the laboratory and the end-user using virtual globe facilities. The Visualization module and Dataset are the main purpose of the present work. The dataset encompasses 11 years of MODIS and TRMM time series. The algorithm module includes non-linear techniques and computational operators derived from the Gradient Pattern Analysis [Rosa et all. 2000], Detrended Fluctuation Analysis [Peng et al., 2005] and Recurrence Plot Analysis [Marwan et al., 2007]. These techniques are not described in this work.

The MODIS images were acquired at the portal Warehouse Inventory Search Tool WIST NASA (https://wist.echo.nasa.gov) for all South America geographical region. The selected product was the MOD13Q1 (collection 5) that is the composition of 16 days at spatial resolution of 250 m. A total of 6,293 files were acquired corresponding to 3.5 TB of raw data. The vegetation index chosen for the present study is the EVI2 (Enhanced Vegetation Index 2) which highlights the land cover variations. The original EVI2 time series was filtered using the Daubechies (Db8) orthogonal Discrete Wavelets Transform [Freitas et al. 2011]. The filtering procedure smoothes high frequencies that are associated with clouds cover and sensor noises. The TRMM monthly rainfall data, the accumulated monthly rainfall series (millimeters per month) were constructed based on product 3B43 V6 of TRMM (Tropical Rainfall Measuring Mission) available at NASA's Goddard Earth Science (GES) Data and Information Services Center (DISC) Distributed Active Archive Center (DAAC). This data estimates the accumulated monthly rainfall at spatial resolution of 0,25 deg.

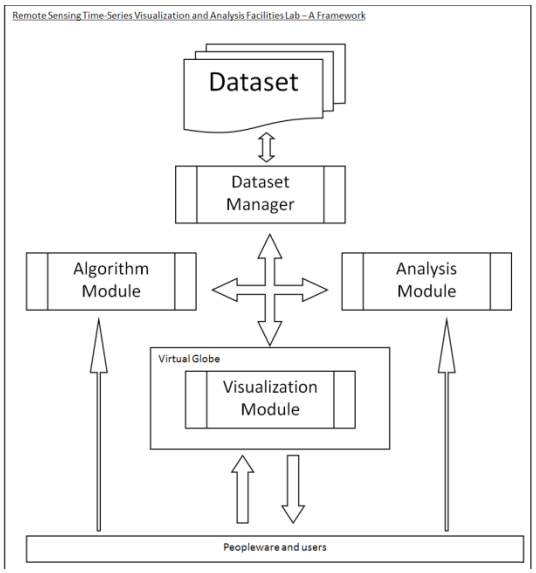

Figura 1. Virtual Laboratory of Remote Sensing Time Series framework [Freitas et. al., 2011].

The EVI2 time series were integrated into the virtual globe (GoogleMaps) using the *Dataset manager* (Figure 1) that was specifically developed for this purpose. To visualize the EVI2 time series in the virtual globe a website was built, that is available at http://www.dsr.inpe.br/laf/series.html, based on JavaScript and PHP platforms using Google Maps and Google Visualization Application Programming Interface functionalities. For each call of a geographic coordinate from the virtual globe the two EVI2 time series are instantaneously recovered. The information of the time series recovered by the call refers to one MODIS pixel.

3. Results

The intense anthropogenic pressure forces the LULC change processes in South America by converting natural forest and savanna areas to pasture and agriculture. The Figure 2-a shows the visualization module interface. The Google Maps image illustrated the forested region with several deforested areas in the municipality of União do Sul in Mato Grosso state, Brazil. The visual analysis of the EVI2 time series (Fig. 2-b) indicates a land conversion from forest to agriculture areas. The red and blue lines represent the time series filtered with wavelet and without wavelet, respectively; located in blue balloon in Figure 2-a. The double arrows illustrate the land use types during the eleven years. The deforestation process started in the first quarter of 2007 and ended in the last quarter of the same year. Analyzing the time series a decrease in the EVI2 values can be observed in 2007 indicating a significant biomass loss due to the deforestation process. From last quarter 2007 to 2008 there was almost no vegetation regrowth as indicated by the low EVI2 profile during this period. For the years of 2009 and 2010 a typical spectral response for agricultural areas can be observed, characterized by a rapid increase followed by a rapid decrease of the vegetation index values indicating the well defined and short growth cycles of agricultural annual crops. The rainfall TRMM time-series (Figure 2-c) indicate dry and wet season during the 11 years. The time-series could be used to understand the vegetation dynamics during for e.g. dry season. It's expected a low EVI2 response during this period in most types of vegetation.

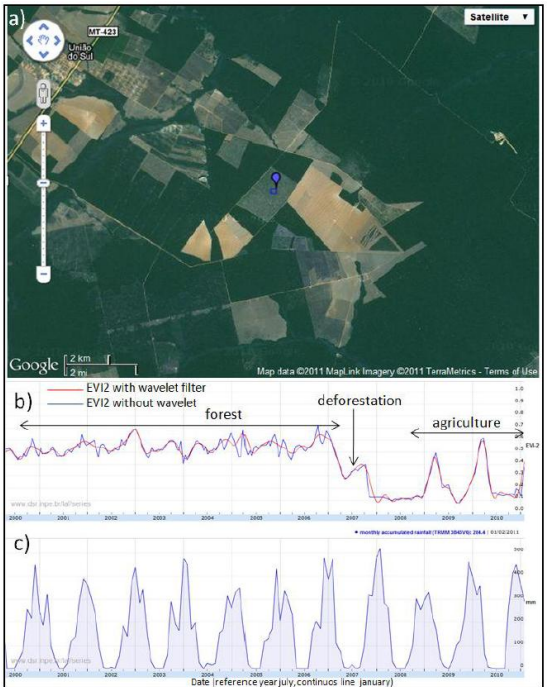

Figura 2. a) GoogleMaps image; b) EVI2 time series plot for the selected coordinated point c) TRMM accumulated monthly rainfall (mm per month) time series plot for the selected coordinated point.

4. Conclusion

This work presented a web tool for the on-line visualization of time series using the eleven years of history of MODIS EVI2 and TRMM time series for the entire South America continent. The visualization tool has been used an ancillary and validation data in the INPE's Earth observation monitoring projects. This work showed an innovation because it allows the general public access and rapid visualization at the pixel level, over large regions. Future works will be focused on providing LULC changes hot spots using computational operators derived from non-linear techniques.

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