USING GRADIENT PATTERN ANALYSIS FOR LAND USER AND LAND COVER CHANGE DETECTION

Ramon Morais de Freitas, Reinaldo Roberto Rosa, Yosio E. Shimabukuro

Instituto Nacional de Pesquisas Espaciais (INPE)
Av. dos Astronautas, 1758 - São José dos Campos, SP, 12227-010, Brazil
E-mail: {ramon, yosio}@dsr.inpe.br; reinaldo@lac.inpe.br

1. INTRODUCTION

The land use and land cover monitoring using remote sensing data is an important instrument for Government policy and surveillance of preservation areas. A near real-time change detection and characterization method would allow control of the increase of new anthropic and natural environmental changes. The LULC changes monitoring allows to understand the spatial patterns and the dynamics. In this context, the work has the objective to propose a methodology to detect and to monitor LULC changes using spatial temporal remote sensing data. Traditional methods of LULC changes detection is based on pattern recognition and statistical measurements, while the proposed method encompasses statistical physics and non linear dynamics concepts [1].

2. METHODOLOGY

The proposed methodology uses Gradient Pattern Analysis [2, 3] a modern technique for analyzing spatially extended dynamics[1]. The measurements obtained from GPA are based on the spatial-temporal correlations between large and small amplitude fluctuations of the structure represented as a dynamical gradient pattern. Based on a scalar elementary field (Fig 1-a) which can be represented by pixels values of an image or subset image in remote sensing, the first moment is represented by gradient field (Fig 1-b), the second and third moments (Fig 1-c) is a norm and phase representation , respectively, for each element of the first moment. The fourth moment (Fig 1-d) is the Euler's formula for complex representation of the first gradient moment which shows the relationship between the trigonometric and the complex exponential functions. By means of four gradient moments is possible to quantify the relative fluctuations and scaling coherence at a dynamical numerical lattice and this is a set of proper measures of the pattern complexity and equilibrium. In this work, the GPA technique was applied for the

[1] Statistical physics concept that is related to 2-D spatial pattern marked by gradual changes through a series of states

first time in MODIS spatial-temporal images over the Amazon region. The GPA objective was characterizing small symmetry breaking, amplitude and phase disorder due to spatial-temporal fluctuations driven by the deforestation and flooded changes detected by MODIS images.

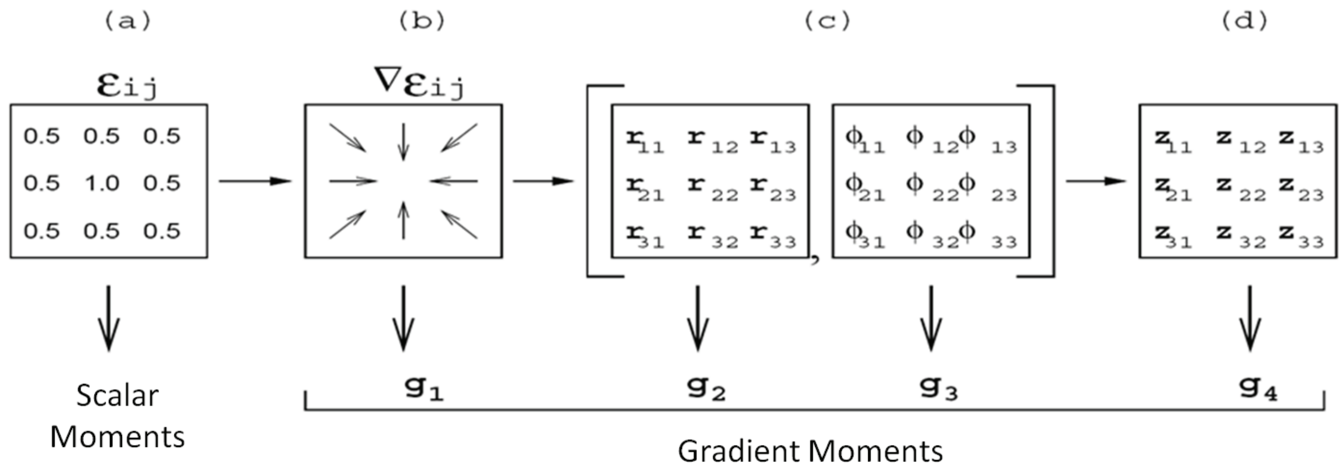

Figure 1 - Gradient Pattern Analysis - The gradient moments

Source: [2,3].

The study area is located in the Pará State, eastern Brazilian Amazonia. The test site encompassing several landscape types as tropical forest, regrowth, deforested areas, croplands and pasture. It presented high deforestation rates in the last years. In this region, recent drought and flooding episodes occurrences carried out a non usual land cover changes. The samples of land cover classes were collected during 2 field campaigns (2003 and 2009) to be used as ground truth. Using MOD09 8-day composite product from 2000 to 2009 was elaborated the spatial-temporal series. The next step we calculate the Enhanced Vegetation Indices 2 - EVI2 [4] using MOD09 red and near infrared spectral bands for each composite. For each pixel we performed smooth time-series using wavelets transform method for noise reduction [5]. Utilizing field data and photo interpreter experience, 4 regions were selected with land use and land cover changes (i.e. deforestation process and seasonally flooded forest region) for performing the method. For each area that applied GPA technique for the spatial-temporal series were reduced to two gradient moments series using phase diversity and Frobenius norm metrics based on in the second and third gradient moments. The temporal behaviour of these two series indicated a new potential metric to understand the land cover and land use dynamics.

3. RESULTS

Figure 2 shows the multi-temporal images of June for 2000 to 2009 time period. Each image has 25x25 MODIS 250 meters pixels with a total area of 39 km2. Figure 3 shows the scatterplot of phase diversity and norm gradient variables from 2000 to 2009 years. High dispersion region is related to the edge presence due to deforestation and natural contrast regions (i.e. river margin and deforestation areas).

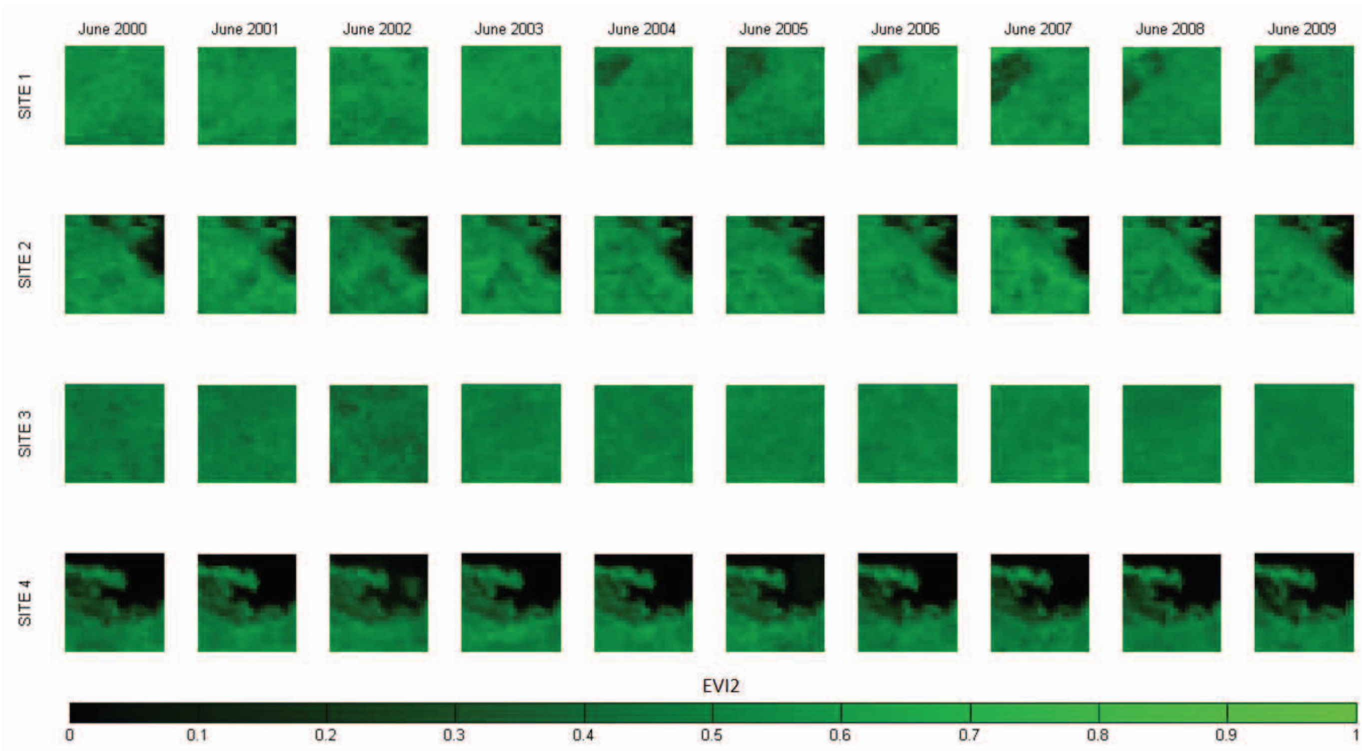

Figure 1 – Multi-temporal EVI2 images for 4 study sites. Site 1 – forest with deforestation activity; Site 2 – deforestation region; Site 3 – forest without deforestation activity and Site 4 – seasonally flooded forest region.

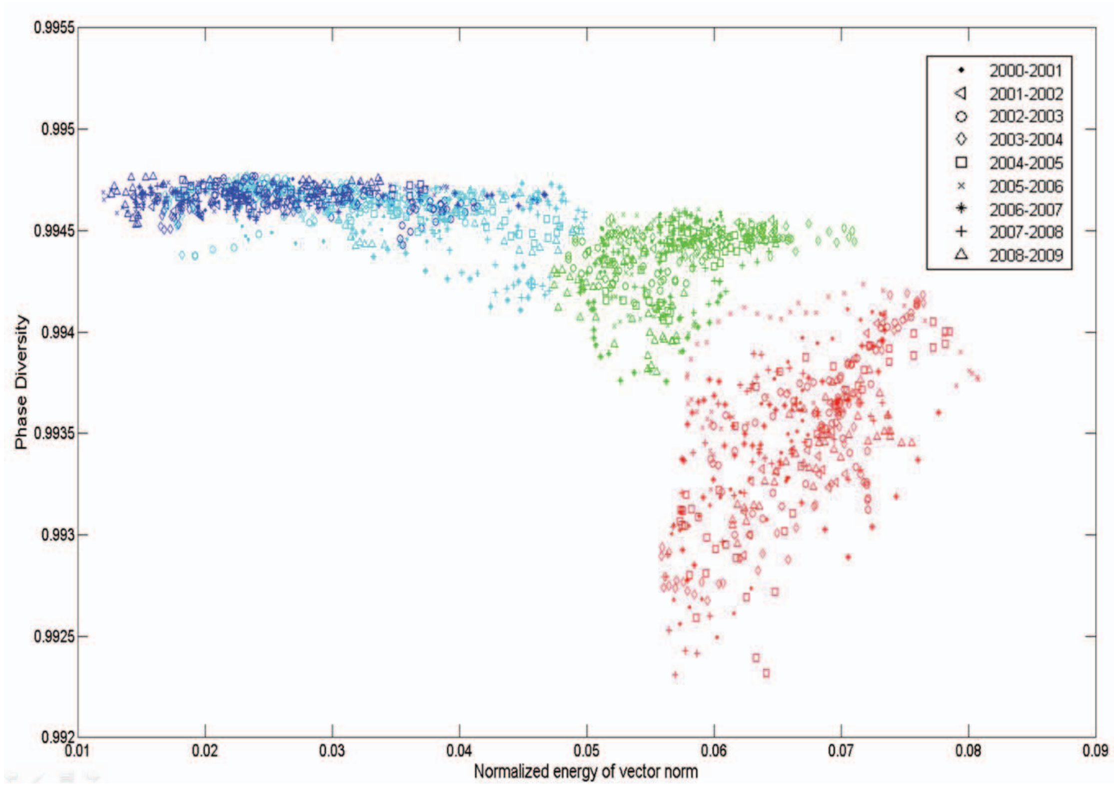

Figure 3 - Scatterplot of Phase Diversity and Normalized energy of vector norm. Cyan - Site 1 ; Green - Site 2; Blue - Site 3; and Red - Site 4.

4. CONCLUSION

For the characterization of spatial-temporal time series the Gradient Pattern Analysis showed a new approach to reduce the dimensionality of data. This is important for deforestation detection and characterization in large geographic regions as Amazonia.

REFERENCES

[1] H.E. Stanley, "Phase Transitions, Power laws and universality". *Nature* , 378 , 554. 1995.

[2] R.R. Rosa, A.S. Sharma, J.A. Valdivia, "Characterization Of Asymmetric Fragmentation Patterns In Spatially Extended Systems" *Int. J. Mod. Phys.C*, 10(1), p.147. 1999.

[3] F.M. Ramos, R.R. Rosa, C. Rodrigues Neto, A. Zanandrea. "Complex Entropic Forms for Gradient Pattern Analysis of Spatio-temporal Dynamics", *Physica A*, p.283, 171 2000.

[4] Z. Jiang, A. R. Huete, K. Didan,, T Miura. "Development of a two-band Enhanced Vegetation Index without a blue band", *Remote Sensing of Environment*, 112(10), p 3833-3845. 2008

[5] R. M Freitas, Y. E. Shimabukuro . "Combining wavelets and linear spectral mixture model for MODIS satellite sensor time-series analysis", *JCIS - Journal of Computacional Interdisciplinary Sciences*, v. 1, p. 51-56, 2008.