Revista GEOGRÁFICA VENEZOLANA | Volumen 58(2)2017 julio-diciembre
ISSNp 1012-1617 /ISSNe 2244-8853
RECIBIDO: septiembre, 2016 **ACEPTADO**: diciembre, 2016
pp. 306–319

Analysis of segmentation

and validation of data of the Landsat 8 for Goias and Federal District/Brazil

Análise de segmentação e validação de dados do Landsat 8 para Goiás e Distrito Federal/Brasil

Daniel de Oliveira Soares

Elaine Barbosa da Silva

Universidade Federal de Goiás, Samambaia Campus II,
Laboratório de Processamento de Imagens e Geoprocessamento /
Instituto de Estudos Sócio Ambientais (UFG/LAPIG/IESA), Goiânia,
Goiás (GO), Brasil
ddsoares@gmail.com; elainesilvafg@gmail.com

Abstract This study aimed at analyzing the most adequate methods to make the classification / segmentation between two distinct computer programs, Spring and Envi, and to analyze and validate data mapping of TerraClass Cerrado 2013 from classes of pasture, annual agriculture and perennial crops. Twenty-four scenes of Landsat 8 OLI corresponding to the surfaces of State of Goias and Federal District were selected. Several targeting tests were made with several images to investigate both feasibility and reliability of the software under study. As a result, mapping made from TerraClass Cerrado 2013 validated the data from the three classes. It has been used Visual inspection techniques using high resolution satellite images and time series. Results showed reliable, available, and free techniques for analysis and validation of data mapping.
Palabras clave: Landsat; land cover and land use; cerrado, TerraClass.

Resumo *Este estudo teve como objetivo analizar os melhores métodos para fazer as classificações / segmentações entre dois programas distintos, Spring e Envi e analizar e validar os dados do mapeamento TerraClass Cerrado 2013 nas classes de pastagem, agricultura anual e agricultura perene. Para isto, foram selecionadas 24 cenas do Landsat 8 OLI, que cobrem todo o estado de Goiás e Distrito Federal. Foram feitos vários testes com várias imagens, para investigar a viabilidade e confiabilidade do software testado. Após os testes, foram feitas as validações do mapeamento do TerraClass Cerrado 2013 em três classes, pastagem, agricultura anual e perene. Foram utilizadas técnicas de inspeção visual com imagens de satélite de alta resolução e também o apoio de séries temporais. O trabalho mostrou resultados satisfatórios porque identificou técnicas confiáveis, acessíveis e gratuitas para análise e validação de dados de mapeamento disponíveis.*
Palavras-chave: *Landsat; cobertura e uso da terra; cerrado, TerraClass.*

1. Introduction

Considered one of the 34 hotspots for biodiversity conservation in the world (Myers *et al.*, 2000). The Brazilian Cerrado is a vast and extensive dimension region, comprising various transition ecotones (Cerrado-Amazon, Cerrado-Caatinga and Amazon-Caatinga). Its scope is an area of 2,039.387 square kilometers or 23 % of the Brazilian territory (IBGE, 2004).

Cerrado from at 1970s, noticeably felt an intense process of use and human disturbance of its landscape, with the change of the capital of Brazil to Brasília, and the incentives that the government offered for the implementation of agriculture within the country in addition to the advancement of agricultural techniques (Ramalho Filho *et al.*, 1978; Ramalho Filho & Beek, 1994; Silva, 2013).

The development of the region had brought several consequences. The main one was increase in human activities, with the decline of native vegetation (Silva, 2013). Deforestation increased due to pressure for the expansion of the agricultural frontier (Miziara & Ferreira, 2008). Allied with the consequences, deforestation of the Cerrado biome presented index of 6.3 % between 2002 and 2008, increasing the converted area of 41.9 % to 48.2 % of the total Cerrado area (MMA, 2007; Sano *et al.*, 1999; 2010). Another relevant point to be raised should be attributed to fire. Since the intensification of agriculture in the region and the anthrop practice of land use, as well as great occupation, deforestation for pasture and cattle management, burning has been a major problem of environmental concerns and the conservation of the Cerrado biome (Coutinho, 1990; Rivera-Lombardi, 2003).

In this sense, this research sought to identify the best and most practical satellite images segmentation of the Landsat 8 OLI in two different softwares, seeking to distinguish their capabilities, practicalities and facilities for various purposes. To sought to create a monitoring of land use vegetation cover for the Cerrado biome, specifically in the year of 2013, and 1:250,000 scale, in the territorial part of Goias and Federal District and to validate these TerraClass Cerrado 2013 data, as inputs to understand and verify the quality of the data mapped in the pilot project.

2. Metodology

The acquisition of the series of images was performed by the digital catalog of the US Geological Survey Department (USGS). The set of images obtained from satellite Landsat 8 OLI, in 2013. In all, the study involved 72 pictures; each one picture has 3 scenes to perform the color composition **(Figure 1)**.

In choosing the preferred images to images of August or September, with not up to 10 % cloud cover, with fewer clouds, it will be better the image. To be images already recorded automatically from the calibrations of the satellites, the following was the color composition of images (RGB) in bands 4, 5 and 6. It has been used the Envi 5.0 software for that procedure.

It made two tests with the segmentation/classification of images. In the first test we proceeded to the supervised classification with the method Bhattacharya from Spring software with the following parameters: 35 % similarity, minimum area of 20 pixels, 15 subjects and 25 interactions. The choice of the samples took about 2 hours the export of the raster to vector required about 12

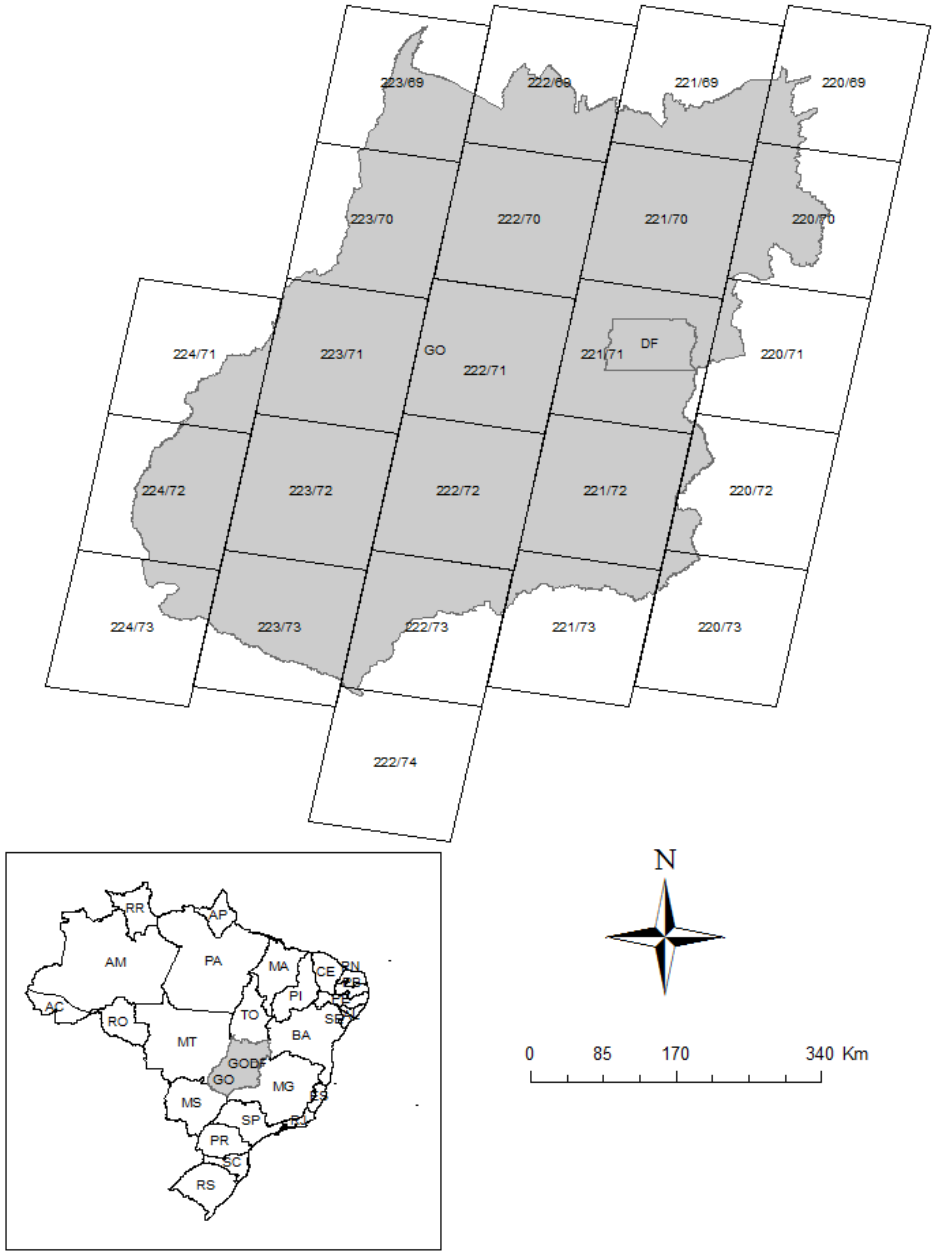

Figure 1 Scenes selected for mapping and validation of TerraClass Cerrado Project superimposed on the map coverage and land use within the state of Goias and the Federal District. Adapted from IBGE data

hours of processing. Because it is savanna vegetation there was much confusion targets, particularly among natural vegetation and pasture natural or artificial, which prevented the resulting classification, even for correction, as shown in **figures 2A** and **2B**.

The second test of segmentation/classification adopted segmentation of images from Envi 5.0 software. With the tool Feature extraction-example based was adopted the following parameters: segmentation for Edge algorithm with level scale of 40 to 55, merge with Full Lambda Schedule algorithm with level of 90 to 97 and texture like 3 kernel size. In **figure 3** is an example of segmentation using that tool, from Envi software.

The third and final test of segmentation/classification consists in the adoption of visual inspection of all the polygons generated by the two software distinctly. For that we considered all the polygons as vegetation and the classification of polygons contain uses following classes were assigned: agriculture, pasture, water body or urban area **(Figure 4)**.

Figure 2 A) Landsat image unclassified (RBG 4, 5, 6). *Source*: Author

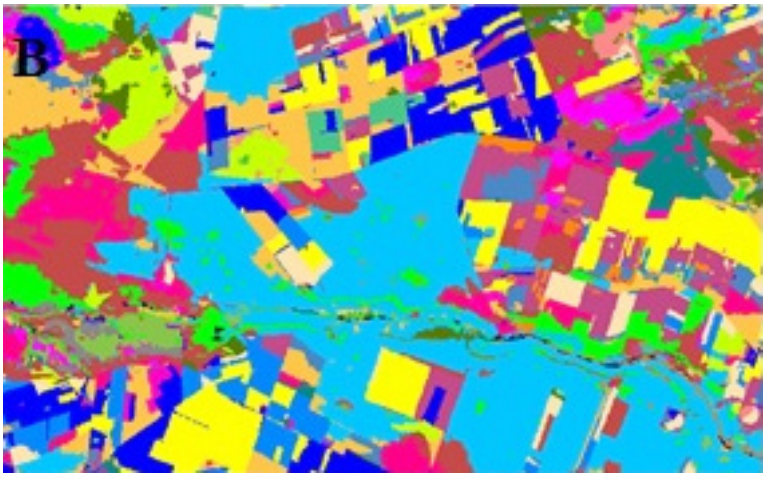

Figure 2 B) Classified image in the Spring software, demonstrating the confusion between targets. *Source*: Author

Figure 3 Segmentation test done on Envi Feature extraction-example based tool. *Source*: Author

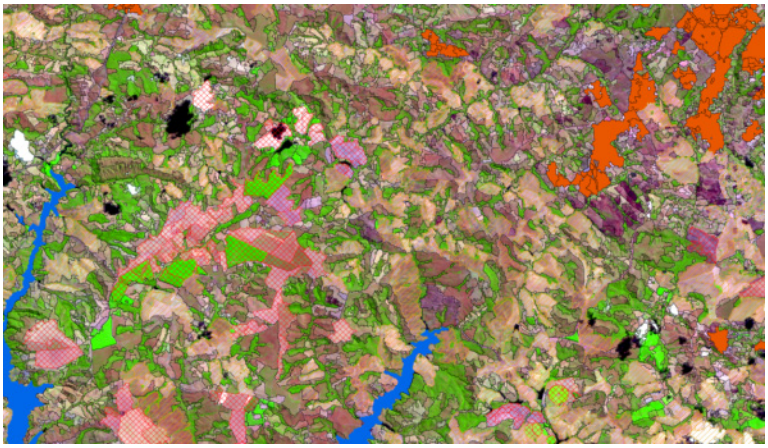

Figure 4 Satellite scene Landsat 8 inspected using hatchers for uses. In that scene, are the five uses (vegetation, water, urban area, pasture and agriculture) differentiated inspection of land use. *Source*: Author

Thus, the visual inspections work also worth to compare the segmentations of Spring and Envi and the formation of polygons. At first, the analysis from the first two tests is the first software, Spring has the advantage of generating polygons with more accurate and smooth edges **(Figure 5)**, with the current parameters a super-segmentation was perceived (generating many polygons), some natural vegetation polygons were confused with exposed soil and raised a number of polygons in the same category. However there is the disadvantage of requiring an average of 17 hours of work.

The second software, Envi generated targeting an average time of 15 minutes of processing, greatly reduced time compared to Spring, with the same images. While it was generated a lot of polygons parameters used. Even with super-image segmentation, the polygons were eventually minimized in comparison to the work time that Spring

would spend to make processing. From the parameters used it was possible to define the categories used for large territorial extensions work. The definition of the polygons is much less checkered and smoothed against the Spring **(Figure 6)**.

From that phase of work, TerraClass Cerrado 2013 mapping data were used anthropic coverage: annual agriculture, perennial agriculture and pasture. Although there are several other classes in TerraClass Cerrado mapping. The choice of the three selected classes was because of Goias State to be fully inserted into the Cerrado biome, being with its natural vegetation greatly compromised, because it is one of the largest soybean producers and the country's sugar cane, also it is the stage of the advance of the agricultural frontier from the beginning of the 1970s it intensified from the southwest region of the state of Goias, thus contributing to an overview of a medium extremely damage environment and the challenge of continuing to advance an economic activity that has given development to the country, but compromising natural resources and

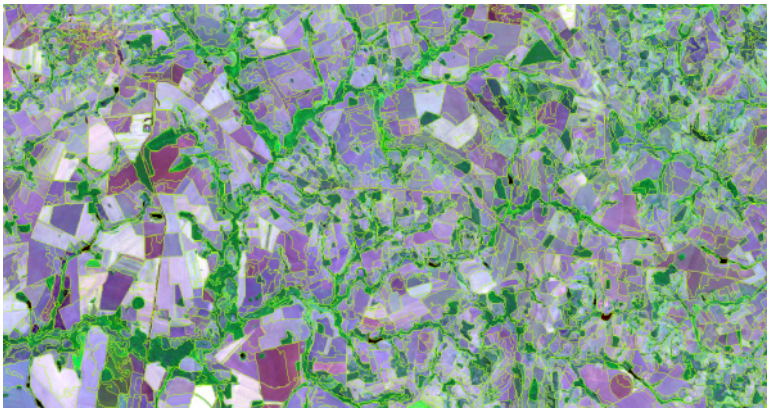

Figure 5 Segmentation scene of polygons with parameters used in Spring software. *Source*: Author

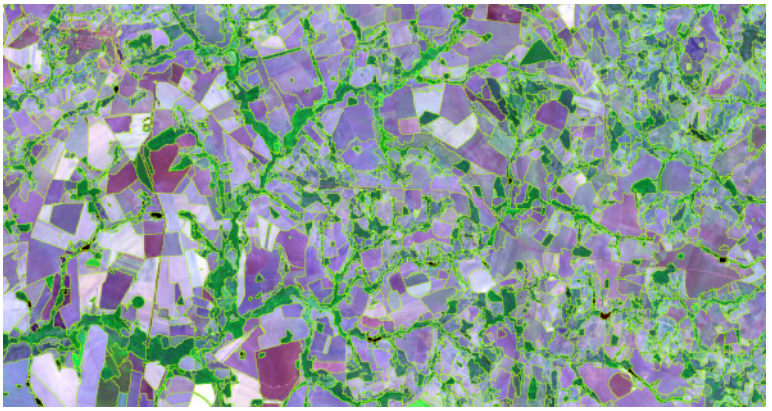

Figure 6 Scene with segmentation of polygons with parameters used in Envi software. *Source*: Author

biodiversity (Silva, 2013). TerraClass Cerrado mapping used the 2013 data and from these data, this project did validations on the results of the presented products.

It was used the QGIS 2.10.1 free software and were used visual inspection techniques for validations. When using as a base high spatial resolution images from Google Earth, the Open Layers from QGIS tool, classes had their validations confirmed as ‹yes› or ‹no›. When was validated in class ‹yes› it was because that class was in line with what was mapped by TerraClass mapping, when it validated the class as ‹no› means that class was not in agreement with what has been mapped in the pilot Project as example in **Chart 1**. In this case, if the class was ‹pasture›, it remained the same class from the validation. Validation as ‹no› was because that class was not consistent with what was to be validated is confirmation from the visual inspection by images of high resolutions, or time series tool.

In **figure 7** there is highlight like an example of visual inspection, made from TerraClass Cerrado 2013 mapping data. As shown in the example below, use classes were selected, such as red, yellow and light green. Already as unselected classes, they are classified as other classes.

For the verification of annual agriculture and perennial agriculture classes was used time series tool from Brazilian Spatial Research Institute –LAF-INPE– environment for visualization and analysis of land use change and land cover from vegetation indices **(Figure 8)**. By identifying the class, the time series will open a frequency plot of that pixel. How higher the frequency in the graph, greater the cycle usage in that polygon. Depending on the frequency of changes in vegetation indices during the year, it gave to understand if the pixel was an annual or perennial agriculture. At the annual agriculture, the cycle is short for plantation renewal and for perennial agriculture, the cycle is long or permanent. For example, a sugar cane plantation part of a short cycle, that is, an annual agriculture and has a high frequency in time series. Already an orange plantation is considered as evergreen agriculture long cycle or permanent. The calculation of vegetation indices uses MODIS images from MOD13 product (Jiang *et al.*, 2008).

TerraClass Cerrado 2013 already represents improvements in the subsidy provision to enhance the monitoring and Cerrado management by providing systematic mapping of the use and coverage of land,

Chart 1 Example of classes referring to a scene which comprises the state of Goias, the scene 220/69. Classes validated as 'yes' and 'no' express area in km². Adapted from TerraClass Cerrado 2013 data

TerraClass Cerrado Project			Validations	
Orbit/Point	**Avaliable classes**	**Polygons quantify (Fid) by semi-automated classification/TerraClass (km²)**	**Yes**	**No**
220/69	Pasture	10690	10677	13
	Annual Agriculture	15622	15394	228
	Perennial Agriculture	403	403	0

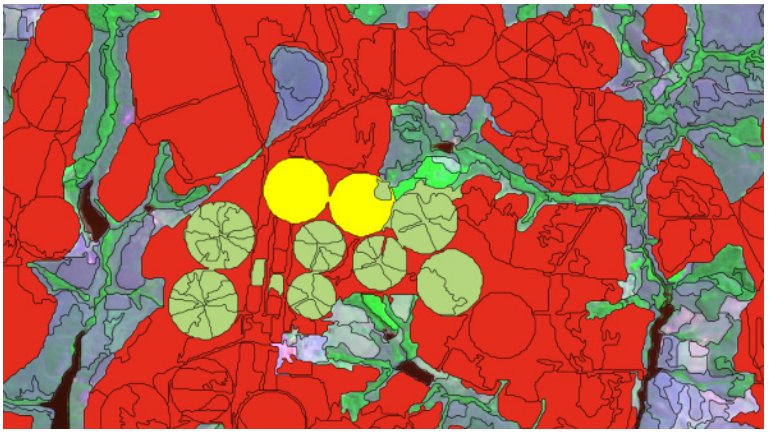

Figure 7 Visual inspection of the pasture class in QGIS software.
Source: Author

Figure 8 Time series to available of frequency of the land use (annual agriculture).
Source: Time series tool –LAF–INPE

highlighting the natural and anthropogenic areas on the scale of 1:250,000. However, although the accuracy of the TerraClass Cerrado mapping is considered high, yet there are inconsistencies in small areas and that should be corrected from the monitoring on the use of the soil.

Given the universe of thousands of classes, validation showed that TerraClass Cerrado has a reliability in which most classes are validated in accordance with the initial mapping (Figure 9).

In the flowchart are presented all the methodological procedures and the steps of the research that took place between the years 2014-2016 (Figure 10).

After the data are validated, a map of land use and land cover for Annual Agriculture, Perennial Agriculture and Pasture was generated for Goias and Federal District (Figure 11).

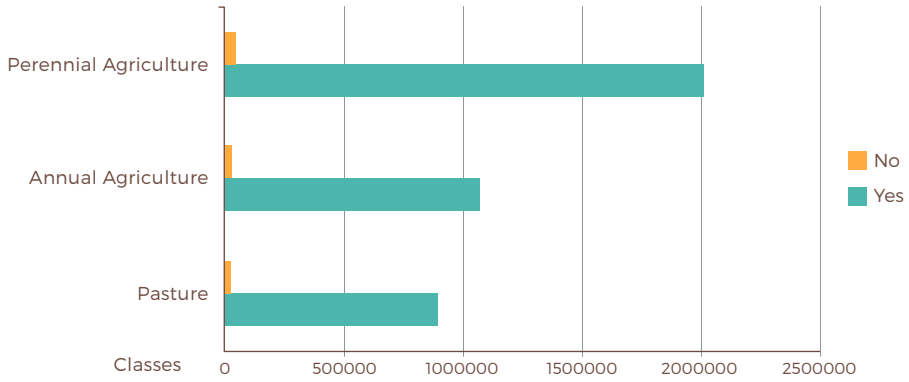

Figure 9 TerraClass Cerrado classes amount validated as ‹yes› or ‹no› to the validations of the state of Goias and Federal District. *Source*: Author

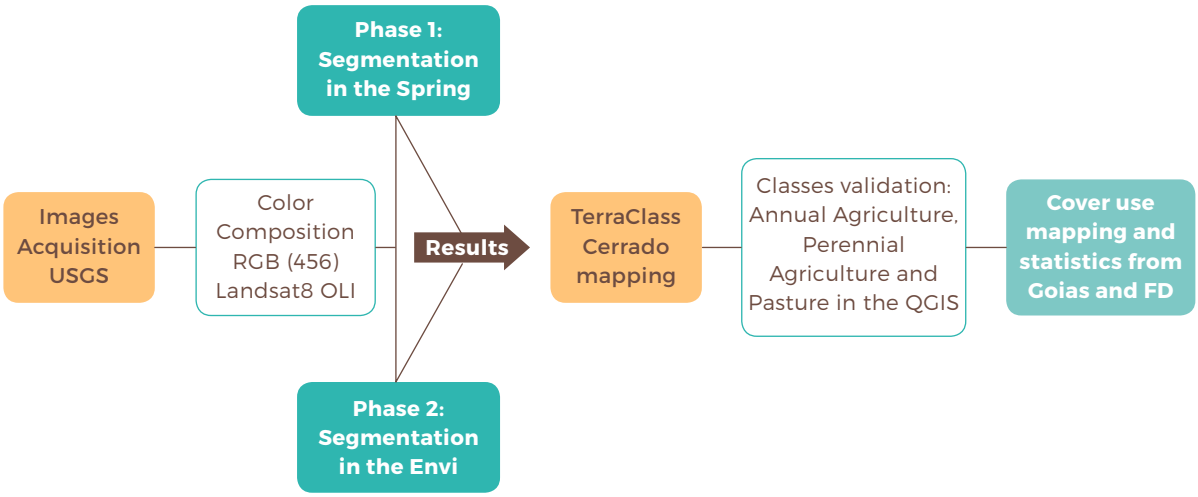

Figure 10 Flowchart of methodological work steps for use and land cover, visual inspection and validation of TerraClass Cerrado data. *Source*: Author

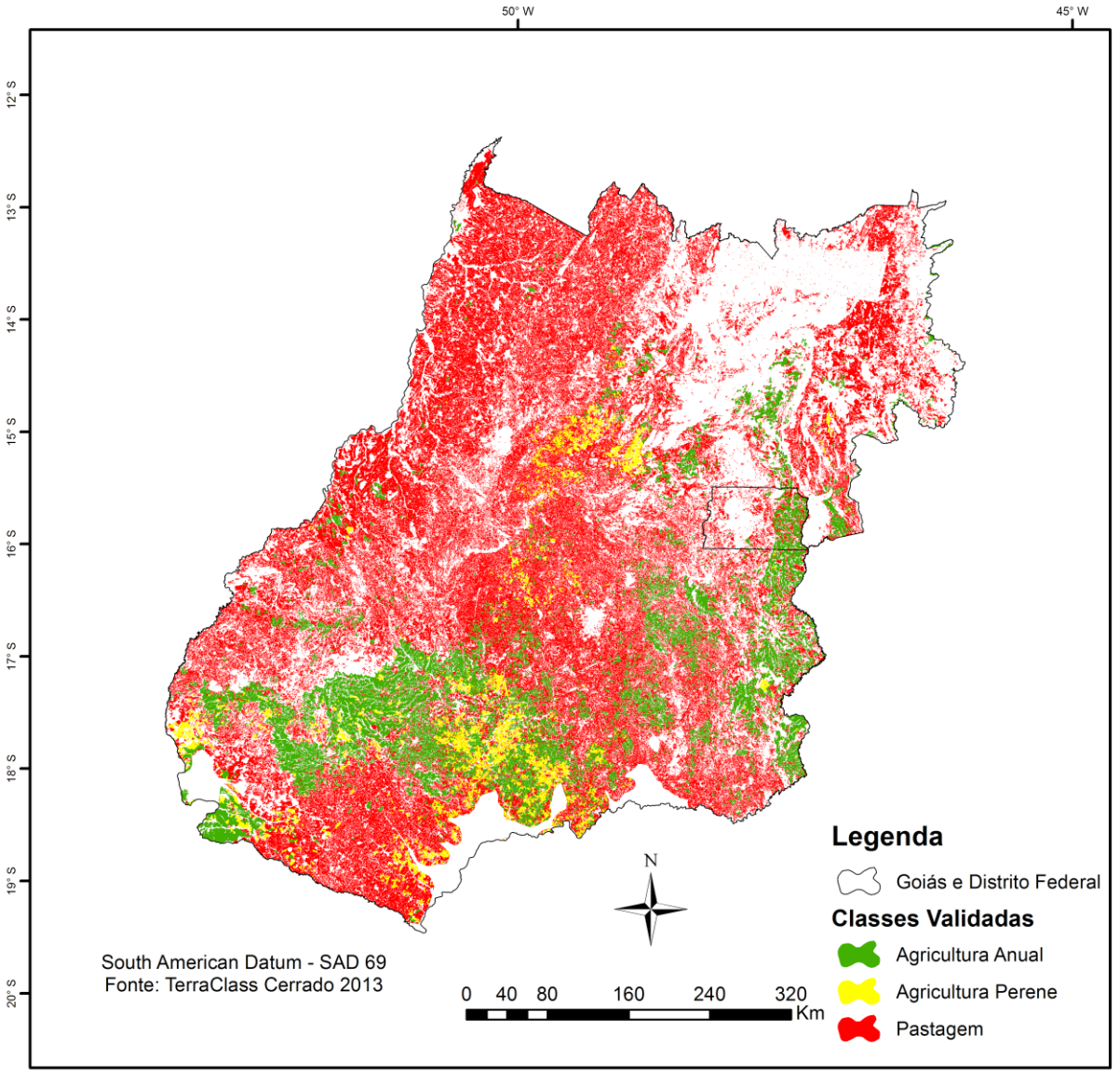

Figure 11 Annual Agriculture, Perennial Agriculture and Pasture classes validated in relation to TerraClass Cerrado mapping (2013). Adapted from TerraClass Cerrado 2013 data after validation

3. Results and discussions

In the first part of the project, segmentations comparison of two different software, Spring with free and Envi with pay license was made. The first software has the advantage of generating polygons with more accurate and smooth edges, but the disadvantage was require an average of 17 hours of work to get the polygons of an image, and therefore suitable only for regions where there are many use and land use. The second software generated segmentation an average of 15 minutes of processing and more squared and specific polygons. This quickly proved

to be too important enough to check in early visual inspection when the polygons would be unadjusted to the interest of the work, to be then possible to adjust the merge, procedure easily performed even after making segmentation. The latter software is easier to work with large areas and historical maps for biomes, population, use and occupation of land, etc. In the second part of the project, it used the TerraClass Cerrado mapping, which corresponds throughout the state of Goias and Federal District to validate Annual Agriculture, Perennial Agriculture and Pasture classes. Validations were able to demonstrate that even the work being automated, your accuracy is never total. Therefore, any and all work is subject to correction and improvements. Validations have not found a large margin of error to which it was possible to see the quality of work and the TerraClass Cerrado team.

The good spatial resolution of Landsat 8 images, which despite being in medium spatial resolution is interesting to validate the use and occupation of land for your update frequency available and can always be updating the data and their own gratuity pictures that makes this product is one of the most important imaging number of groups Earth. Speaking about Cerrado, a biome of huge spatial dimensions, with its own characteristics and undergoing intense uses and occupations in the territory, in terms of quantify and quality of research is encouraged enough with the gratuity of this vast collection, which in summary enabled and enables high-quality and low-cost research.

Given these facilities, to make any spatial analysis work on a scale that covers the state of Goias and the Federal District, for example, in the scale of 1:250.000, with a huge land area and wealth of detail concerning the use and occupation of land, segmentation/classification made in Envi software was more feasible before rapid, efficient and detailing the level of merge, as well as minimizing the generation of polygons. Data analysis for the validation of TerraClass Cerrado, a mapping that was already available to the company, has chosen to already existing, safe and reliable techniques, as visual inspection from other available resources and the use of time series tool provided by Brazilian Spatial Research Institute -INPE, for free. The accuracy of these assessments was high, above 90 % of validated classes and the state of Goias, these validations can be extended to other contexts and environmental studies.

4. Final considerations

However, until then, this work could make a brief comparison between two most common software used for remote sensing, Spring as free and Envi as paid software. This comparison was based on comparing the methods of segmentation and classification of these images, in addition to highlighting positives and negatives. Through this methodology, it was possible to obtain methodological and scientific. Synthesis between the two software, its difficulties, features, and gains and a better understanding of its priorities, depending on the scale of the work. To be made to compare the two software, it was possible to obtain important information from this work, to continue the use of this tool is to segmentation the entire state of Goias and Federal District, or others studies.

In the validation of TerraClass 2013 Cerrado data it was possible to use the

usual technique of visual inspection that already has as methodology known in the characterization of land use and occupation. Landsat 8 OLI images satellite series for the year 2015/2016 were also used as validation feature in the item update.

TerraClass project already has a mapping version to Amazon and recently in 2013; the version is mapped to all the Brazilian Cerrado, in order to provide systematic mapping of the use and coverage of land, highlighting the natural and anthropogenic areas in the scale of 1:250.000. Result of this project was evaluated as successful and with high reliability by reason of high accuracy. By validating data for the TerraClass Cerrado for the state of Goias and Federal District, it was found that despite this great reliability of the initial mapping, for a study of use and occupation of land, the more accurate and updated mapping is better to study consequently more results will be possible to be obtained. Challenge for the TerraClass Cerrado is increasingly improve the accuracy of mapping and monitoring that can be updated at least a considerable frequency for large areas.

5. References quoted

COUTINHO, L. M. 1990. «Fire in the ecology of the Brazilian cerrado». In: J. G. GOLDAMMER (ed.), *Fire in the tropical biota*. pp. 82-105. (Ecologycal Studies, 84), Springer-Velarg. New York.

INTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). 2004. *Mapa de Biomas do Brasil, primeira aproximação*. Available in: https://www.ibge.gov.br. Rio de Janeiro, Brasil. [Visit: April, 2015].

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE) – *Tutorial para segmentação no SPRING.* Available in: http://www.dpi.inpe.br/spring/portugues/tutorial/segmentacao.html. [Visit: January, 2014].

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE) – Series Views – *Ambiente para visualização de séries temporais para análise de mudanças de uso e cobertura da terra* - LAF. Available in: https://www.dsr.inpe.br/laf/series/. [Visit: April, 2016].

ITT Visual Information Solutions. 2008. *ENVI Feature Extraction Module User's Guide*. Feature Extraction Module Version 4.6., 78p. Available in: https://www.exelisvis.com/portals/0/pdfs/envi/Feature_Extraction_Module.pdf. [Visit: February, 2014].

JIANG, Z.; HUETE, A. R.; DIDAN, K. & T. MIURA. 2008. «Development of a two-band enhanced vegetation index without a blue band». *Remote Sensing of Environment*, 112 (10): 3.833-3.845. Available in: http://www.sciencedirect.com/science/article/pii/S0034425708001971. [Visit: May, 2016].

MIZIARA, F. & N. C. FERREIRA. 2008. «Expansão da fronteira agrícola e evolução da ocupação e uso do espaço no estado de Goiás: subsídios à política ambiental». In: L. G. FERREIRA (Org.), *A encruzilhada socioambiental: biodiversidade, economia e sustentabilidade no cerrado*. pp. 107-125. Editora UFG. Goiânia (GO), Brasil.

MINISTÉRIO DO MEIO AMBIENTE (MMA). 2007. *Mapeamento da cobertura vegetal do bioma cerrado*. Relatório final. Edital Probio 02/2004. Projeto Executivo B.02.02.109. Brasília, Brasil.

MYERS, N.; MITTERMEIER, R. A.; MITTERMEIER, C. G.; FONSECA, G. A. B. & J. KENT. 2000. «Biodiversity hotspots for conservation priorities». *Nature*, 403: 853-858.

RAMALHO FILHO, A.; PEREIRA, E. & K. J. BEEK. 1978. *Sistema de avaliação de aptidão agrícola das terras*. Empresa Brasileira de Pesquisa Agropecuária. Rio de Janeiro, Brasil.

RAMALHO FILHO, A. & L. J. BEEK. 1994. *Sistema de avaliação de aptidão agrícola das terras*. (3 Ed.) EMBRAPA/CNPS.

RIVERA-LOMBARDI, R. J. 2003. *Estudo de recorrência de queimadas e permanência de cicatrizes de fogo em áreas selecionadas do cerrado brasileiro, utilizando imagens* TM/LANDSAT. 2003. 172 p. (INPE-12663-TDI/1006). Instituto Nacional de Pesquisas Espaciais (INPE). São José dos Campos (SP), Brasil. Dissertação de Mestrado em Sensoriamento Remoto.

SANO, E. E.; BARCELLOS, A. & H. S. BEZERRA. 1999. «Área e distribuição de pastagens cultivadas no bioma Cerrado». *Boletim de pesquisas, Planaltina*, 3: 1-21.

SANO, E. E.; ROSA, R.; BRITO, J. L. S. & L. G. FERREIRA. 2010. «Land cover mapping of the savanna region in Brazil». *Environmental Monitoring and Assessment*, 166: 113-124.

SILVA. E. B. S. 2013. *A dinâmica socioespacial e as mudanças na cobertura e uso da terra no bioma Cerrado*. 148 f.: il. Universidade Federal de Goiás. PPGEO, Goiânia-GO, Brasil. Tese Doutorado em Geografia. Available in: http://www.lapig.iesa.ufg.br/lapig/index.php/produtos/apresentacoes/viewdownload/9-tese/801-a-dinamica-socioespacial-e-as-mudancas-na-cobertura-e-uso-da-terra-no-bioma-cerrado. [Visit: November, 2015].

UNITED STATES GEOLOGICAL SURVEY (USGS). *Earth Explorer*. Available in: http://earthexplorer.usgs.gov/. [Visit in: August, 2015].

Lugar y fecha de finalización:
Goiânia, Goiás (GO), Brasil;
julio, 2016