Accuracy assessment of deforestation datasets for the Amazonian state of Rondônia, Brazil

Eraldo Aparecido Trondoli Matricardi[1]*, Marcos Antonio Pedlowski[2], Valderli Jorge Piontekowski[1], Luis Cláudio Fernandes[3]

[1]Universidade de Brasília, Departamento de Engenharia Florestal, Campus Universitário Darcy Ribeiro, 70910-900, Brasília, DF, Brazil.

[2] Universidade Estadual Norte Fluminense, Campos dos Goytacazes, RJ, Brazil

[3]Secretaria de Estado do Desenvolvimento Ambiental, Estrada do Santo Antônio, 900, Bairro Triângulo, Porto Velho, RO, Brasil

Autor Correspondente:

*E-mail: ematricardi@gmail.com

Abstract

This study aimed to assess the accuracy of the deforestation datasets developed by the National Institute for Spatial Research (INPE) and by the Rondônia State Environmental Secretariat (SEDAM), both based on Landsat imagery and remote sensing approaches. Those datasets have been used to support climate change studies and environmental impact assessment programs from the local to regional level. We have used two high spatial resolution SPOT images acquired in 2010 to estimate mapping accuracy for each deforestation dataset. The SEDAM and INPE datasets showed similar overall accuracies (94.8% and 93.3%, respectively). The classification conducted by SEDAM seemed to be more conservative than INPE´s classification because of its lower commission error for the deforestation class. Based on SEDAM dataset, we estimated a four-fold decrease in deforestation rates in Rondônia between 2002 and 2011. However, illegal deforestation inside of protected areas showed a substantial increase (approximately 480%) in the same period of time. We expect that deforestation will substantially increase within protected areas in the Amazon if the Brazilian environmental laws are not fully enforced there.

Keywords: Accuracy assessment, deforestation, Brazilian Amazon, Rondônia, PRODES, SEDAM.

1. Introduction

The Brazilian Amazon Basin was targeted by the Federal government for agrarian colonization projects since the 1970s (Brandão and Souza, 2006; Tourneau and Bursztyn, 2010). In the state of Rondônia, this occupation process caused the highest deforestation rates within the region during several decades. As a result, large tracts of tropical evergreen forests were converted into agriculture (Tourneau and Bursztyn, 2010).

In 1988, the National Institute for Spatial Research (INPE) begun to measure deforestation for the entire Brazilian Amazon in an effort to assist the governmental agencies responsible for environmental protection (Shimambukuro and Smith, 1991). In addition, the government of Rondônia has also launched a deforestation monitoring program through the Rondônia State Environmental Secretariat (SEDAM). The datasets created by INPE and SEDAM were based on Landsat imagery, and they have been used to support global climate change analyses and environmental impact assessment programs from the local to the regional level.

Dataset quality is crucial to support users that depend on geospatial data to conduct environmental analysis (Lingnau and Antunes, 2003). Lingnau & Antunes (2003) affirm that there are several sources of error regarding digital data that can be caused by the observer and/or the measuring devices used during data acquisition. Errors can be classified as systematic or random and they must be assessed to better estimate data quality (Thapa and Bossler, 1992). However, data accuracy has yet to be thoroughly assessed on INPE´s and SEDAM´s datasets.

In the present study, we assessed the accuracy of the deforestation datasets developed by INPE and SEDAM for Rondônia from 2001 to 2011. The SEDAM deforestation dataset relied on eye-inspection of Landsat-5 TM imagery. In this case, new deforestation plots that showed obvious forest canopy changes were mapped by digitizing each unit identified on the computer screen.

On the other hand, the PRODES classification is based on fraction images (shade, soil, and vegetation) derived from Spectral Mixture Analysis and on unsupervised classification. This classification method is based on the ISOCLUSTER algorithm and it uses Soil, Shade, and Vegetation fraction images to detect annual land use and land cover changes in the Brazilian Amazon (Câmara et al., 2006). The PRODES dataset applied seven land use and land cover classes: total deforestation by 1997; annual deforestation increase (from 2000 to 2012); forests; non-forests (Savannah and other vegetation types); water bodies; clouds, and shadows. The PRODES deforestation mapping was reclassified into two classes (forest and deforestation) for each year in the study period; and water bodies; clouds; and shadows classes were not considered in this analysis. Both datasets were geometrically system-corrected using Ground Control Points as input for a polynomial distortion model and nearest neighbor re-sampling technique. The root-mean-square (RMS) positional errors resulting from this imagery geometric correction varied between 0.2 and 0.3 pixels.

Two high-resolution and orthorectified SPOT images acquired in 2010 (1542 and 1913) were used as input to assess the accuracy of the deforestation detection techniques used by SEDAM and PRODES. These scenes cover two deforestation frontiers (one new and the other old) in Rondônia (Figure 1). The deforestation dataset used to conduct the accuracy assessment was also acquired in 2010. Four hundred sample points were randomly defined on the two SPOT scenes and on the PRODES and SEDAM deforestation datasets. Each sampling point was eye-inspected on the SPOT images and on both deforestation datasets. The eye-inspection results for each sampling point were then used as input for two confusion matrices to estimate the overall, user, and producer accuracies for each dataset.

The deforestation mapping produced by SEDAM showed a slightly better overall accuracy when compared to PRODES (94,8% and 93,3%, respectively). In addition, the producer errors of 7% and 6% were estimated for the SEDAM and PRODES deforestation mappings, respectively, whilst the user errors were 3.6% and 7.4%, respectively. Further classification accuracy details are presented in Tables 1 and 2.

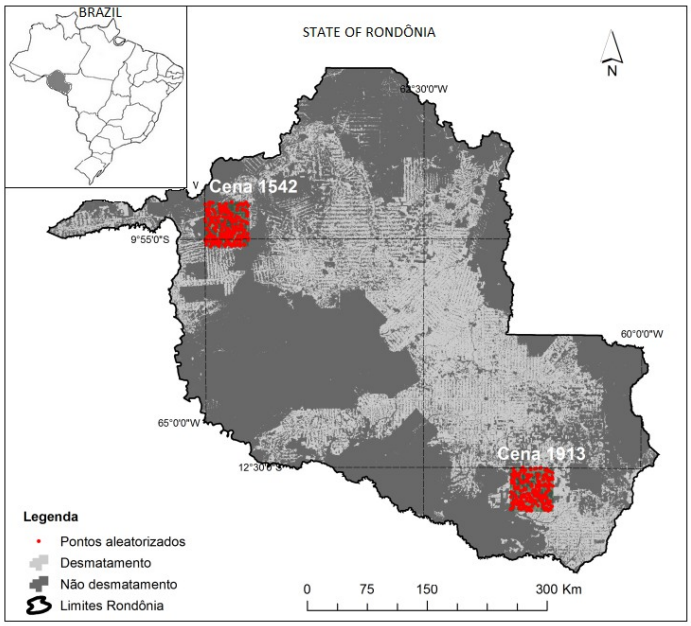

Figure 1. Spatial locations of the random sample points (red color) and two SPOT scenes used for the accuracy assessment of the state of Rondônia deforestation datasets.

Table 1. Confusion matrix for the PRODES deforestation classification.

		Reference data			
Classification	Class	Deforestation	Forest	Σ	Commission error (%)
	Deforestation	**187**	15	202	7,4
	Forest	12	**186**	198	6,1
	Σ	199	201	**400**	
	Omission error (%)	6,0	7,5	Overall error (%)	**6,7**
	Overall accuracy = 93,3%				

Table 2. Confusion matrix for the SEDAM deforestation classification.

		Reference data			
Classification	Class	Deforestation	Forest	Σ	Commission error (%)
	Deforestation	**185**	7	192	3,6
	Forest	14	**194**	208	6,7
	Σ	199	201	**400**	**5,2**
	Omission error (%)	7,0	3,5	Overall error (%)	
	Overall Accuracy = 94,8%				

The results suggest that the deforestation estimates produced by SEDAM are slightly more conservative than those produced by PRODES because of higher omission and lower commission values for the deforestation classes. However, there is a crucial methodological difference between the SEDAM and the PRODES mapping approaches: the former relies on eye-inspection and the later uses semi-automatic classification. This difference may prove the PRODES approach as more responsive

and less time consuming, although with a slightly lower accuracy, to detect and to estimate deforestation for the entire Brazilian Amazon Region. This is a crucial advantage for monitoring deforestation within a territory of $5x10^6$ km^2 which is still mostly covered by tropical evergreen forests.

A great concern of these deforestation datasets, however, is related to important land-use classes that are crucial for global change researches such as estimation of Carbon emission/sink from secondary regrowth, forest fires, and selective logging, which were not detected and estimated in either datasets.

Finally, this research results showed a four-fold decrease in the deforestation rates during the period of study for Rondônia. However, we detected a substantial increase in illegal clearings (approximately 480% within protected areas) for the same period of time. This result is especially important because slashing native forest is not allowed for most of protected areas in the Brazilian Amazon. Given that illegal deforestation is occurring at significant levels inside protected areas, a fact that has been previously observed by Pedlowski et al. (2005) for the case of the Bom Futuro National Forest, one can expect that remaining native forests in Rondônia will be placed under serious risk of complete removal or, at least, of severe degradation in the absence of control measures.

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References

Brandão Jr, A., Souza Jr., C. (2006), Desmatamento nos Assentamentos de Reforma Agrária na Amazônia. *O Estado da Amazônia*, n. 7. Belém: Imazon, 4p.

Câmara, G., Valeriano, D.M., Soares, J.V. (2006), Metodologia para o cálculo da taxa anual de desmatamento na Amazônia Legal. Instituto Nacional de Pesquisas Espaciais– INPE, São José dos Campos–SP. Available at http://www.obt.inpe.br/prodes/metodologia.pdf. Online access on October 28, 2013.

Lingnau, C., Antunes, A.F.B. Avaliação da Acurácia de Mapas Temáticos Oriundos de *Classsificação Digital de Imagens*. SIMGEO, 2003. Disponível em: http://www.cieg.ufpr.br. Online access on September, 21, 2013.

Pedlowski, M.A., Matricardi E.A.T, Skole D, Cameron SR, Chomentowski W, Fernandes, L.C., Lisboa, A. (2005), Conservation units: a new deforestation frontier in the Amazonian state of Rondônia, Brazil. *Environmental Conservation*, Vol. 32(2): 149-155.

Shimabukuro, Y.E., Smith, J.A. (1991), The least-squares mixing models do generate fraction images derived from remote sensing multispectral data. *IEEE Transactions on Geosciences and remote sensing*, Vol. 29 (1): 16-20.

Thapa K., Bossler D.J. (1992), Accuracy of Spatial Data Used in Geographic Information Systems. *Photogrammetric Engineering and Remote Sensing*, Vol. 58 (6): 835-841.

Tourneau, F.M.L., Bursztyn, M. (2010), Assentamentos rurais na Amazônia: contradições entre a política agrária e a política ambiental. *Ambiente & Sociedade*, Vol. 13(1): 111-130.