Analysis of a model for low quality satellite data use on land cover change studies

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Introduction

One of the advantages of the use of satellite images that are somewhat easily available nowadays is the possibility to evaluate land cover changes, which is a fundamental tool for conservation strategies. Availability however is generally associated to poor metadata information, spectral resolution limitations, and sometimes even spatial resolution discrepancies as shown in this work.

Objectives

Our intention is to investigate the possibilities of using low quality satellite images of different scale of resolution in the evaluation of land cover changes in a Cerrado environment.

Methods

A Landsat MSS scene from August 1986 and a TM scene from August 1992 were prepared for a vegetation cover change analysis. The images roughly refer to the area between the parallels 13º and 15º south and the meridians 51º and 53º west. They are from an area in Brazil under an intensive development process for the last two decades, mostly due to agriculture and cattle raising activities. It includes also a large Indian Reservation area on its northeastern part. Quality of metadata is an issue in this study. There was no information about radiometric corrections applied to the images. The geographic projection was not clear in the TM image and not consistent with the coordinates of the MSS image. Therefore, geometric correction was important in the process. Previous radiometric corrections were not considered to be a major problem because the analysis was performed with index images produced with ratio between bands. In this experiment it was used (NDVI) "Normalized Difference Vegetation Index" (Rouse et al. 1974), which is a widely used index for biomass change detection analysis in terrestrial ecosystems with high vegetation cover content (Lyon et al. 1998), combined with the Change Detection Model from the ERDAS Imagine image treatment software. This Change Detection Model is based on the simple image difference between two images where one can determine what percentage of change is to be used as threshold for increase or decrease in the value between the two images. Three approaches for rubbersheet geometric correction between the images were tested: (1) correction of the MSS-NDVI to the TM-NDVI image without any geographic projection; (2) correction of the MSS image to the TM image after projection; (3) correction of the TM to the MSS image after projection with ressampling to the MSS original scale of resolution. A Normalized Difference Vegetation Index Model, which is basically the ratio of the difference between the infrared band and the red band over the sum of those bands (Rouse et al. 1974), was used to produce a vegetation index image from the six images prepared for the land cover change analysis. The Change Detection Model was applied to the three sets prepared for combination of NDVI images. Three thresholds were selected for visual evaluation. 10%, 15% and 20% increase or decrease in the vegetation index values. A visual evaluation of the model results, taking into consideration how well they depicted the most conspicuous changes lead us to select the 15% threshold grid for comparison between the two geocorrections that seems to work. The spectral changes and the patch shapes were used to identify sources of change.A large quantity of scattered small patches was considered consequences of different sources of error, like geometric corrections and image rescaling. Therefore, a further treatment with majority filter with 3x3 window was used to improve the results quality by removing small patches that could be consequences of errors and for an evaluation of the importance of those errors among the three thresholds. The different geometric correction approaches results were evaluated in terms of threshold response and scattered patches intensity considered to be error results. Finally, the accuracies were used to compare the two geometric correction approaches that did not show a clear better performance as far as land cover change identification accuracy. ERDAS accuracy assessment model was run in the filtered version of each of those grids for random selection of pixel samples to be checked. 255 sample areas were visually checked to see if the change detection context indicates real change or error in the classification due to eventualities in the image processing or image defects.

Results

Some very interesting results were observed with this experiment. Our predictions were that the difference in the scale of resolution between the two images would result in a complete distortion of the land cover change analysis results, which turned out not to be the case as observed here. The previous radiance corrections to the images not informed in the metadata was also not an evident factor influencing the results, mainly because the analysis was performed with index images (NDVI) which uses differences and ratios between bands. The geometric correction applied to the images has a high impact on the land cover change results. A previous geographical registering with the right projection definition proved to be essential for the performance of the rubbersheet geometric correction. That can be observed with the complete mismatching of the river as a linear feature when the geometric correction was applied to the unprojected images. Some examples of changes depicted by the analysis are: (a) New agriculture and pastures in large patches or medium to small patches (> 1 ha). (b) Regrowth from burned areas in 86 as well as burned areas between 86 and 92 with some recovery already taken place. (c) Urban development identified and a higher intensity of change associated to the urban center. (d) Slash and burn primitive agriculture observed inside the Indian Reservation as well as new and recovered areas. The land cover change model was able to depict most of the major changes observed in the region. All the large and medium size patches can be explained with a close look evaluation. Small patches some times are real changes other times can be attributed to side effects, like sudden spatial brakes in the land cover type, as edges of water bodies, which could be a real change or just reflect of error due to geometric correction for example. A comparison between the two types of geocorrection treatment showed that a smaller difference in the density between decreased and increased NDVI values is observed when the TM image is rescaled to the MSS scale of resolution. A significant decrease in the area was also observed with this treatment both for the vegetation decrease and increase when the threshold of change is elevated to the 15% level. The 20% threshold level did not decrease significantly the density of pixels classified as decrease or increase in vegetation cover and caused a lot of fragmentation in the patches identified by the model, where a continuous change can clearly be seen. When the MSS image was geocorrected to the TM image, maintaining their different scales of resolution, only the area of vegetation decrease was found to be significantly higher. However, a close observation of the model results show that most of that difference is found in the large patches and therefore can be considered reasonable classification.

Discussion

Despite the fact that the data was of medium quality considering the lack of a complete and clear metadata, results with considerable precision were drawn in relation to land cover change in this area. Even more surprising was the fact that the two images do not even need to be in the same scale of resolution for this kind of analysis. The fact that the MSS image resolution (57m) was exactly twice as large as the TM image resolution (28.5m) may have influenced the good performance of the model for the two different scaled images. It is important to remember that this was possible just because a reasonable geometric registration between the two images could be achieved and an index like NDVI is known to work reasonably in this type of vegetation (Bitencourt et al. 1997).These results demonstrate that even changes that are really hard to identify in the cerrado, like burns with some recovery, can be depicted by this simple procedure. A task not solved yet, and important for management decisions in relation to the Cerrado Biome, is the classification of its different physiognomies using satellite-based images. An evaluation of the landscape features of the Cerrado being affected by the land cover change due to development pressure would be very important tool for conservation actions to prevent biodiversity reduction and ecological processes disruptions.

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