NDVI MODIS SENSOR RESPONSE TO SOYBEAN PHENOLOGY IN THE STATE OF PARANA, BRAZIL

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Abstract: This study aimed to evaluate the response of the *Normalized Difference Vegetation Index* - NDVI derived from Terra MODIS sensor to soybean phenology, in a grain producer region of Parana State, Brazil. Landsat TM and ETM+ images were selected to analyze the spatial distribution of soybean fields for this region from 2000/01 to 2006/07 crop seasons. Then pure pixel samples (250 x 250m) that contained only soybean fields were identified in three locations, based on previously obtained maps from Landsat TM images. The next step was to extract NDVI MODIS values for these soybean pure-pixels and to analyze the NDVI spectral curves considering the soybean phenology for all locations. Several pixels were inspected in order to ensure that a reduction in NDVI values was not caused by the presence of clouds. NDVI values adequately described the soybean phenology, showing soybean growing season (November to March) and the dry season for this region, for all locations in study region.

Key words: NDVI, soybean (*Glycine Max L. Merr)*, remote sensing, phenology.

1. Introduction

Monitoring seasonal changes in vegetation activity and crop phenology over wide areas is essential for many applications such as, the estimation of net primary production, the crop yield modeling as well as the stress detection (Sakamoto *et al.*, 2005). Accurate monitoring of crop development patterns (i.e., phenology and growth) is an important component of land management since it allows assessing if the most critical stages of growth occur during periods favorable to weather conditions. However, according to Viña *et al*. (2004), several dynamic simulation models that compute daily growth and development of a crop often failed when applied in nonoptimal growing conditions (e.g., damaging frost, hail, pests or disease infestation, and/ or drought, among others) and the use of remote sensing data to calibrate the models and adjust for possible improvement in crop health/status has been investigated as useful information. The objective of this study was to evaluate the NDVI MODIS response to soybean phenology in a grain producer region in the State of Parana, Brazil, and also to verify if this vegetation index adequately describes dry periods, during 2000-2007 period.

2. Material and Method

The study region is located in southern Brazil (23°45´00´´; 25°50´00´´South and 49°10´00´´; 51°25´00´´West). Agriculture is the principal land use in the region and the three main crops are soybean, maize and dry bean. The highest yields for a short duration soybean cultivar are obtained when planted in October and November (Heinemann *et al.,* 2002). Soybean cycle lasts 110 days in average and the harvest occurs between March and April in the following year. According to IAPAR (2000) the climate in this region is subtropical humid mesothermic, with warm summers (December–March). Three locations were selected for this study: Candido de Abreu (-24.63; -51.25; 645m); Cerro Azul (-24.81; -49.25; 66m) and Ponta Grossa (-25.21; -50.01; 885m).

Twelve Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) images were used to identify soybean fields during 2000 to 2007 time period. These images were provided by INPE (*National Institute for Space Research* – Brazil). Two phenological stages are important to identify soybean crops in this region: i) November and ii) January/February. In November, during sowing and seedling emergence, there is a strong spectral response from the soil, while in January/February (around maximum vegetative development) the main response is from the crop canopy (Rizzi and Rudorff, 2005). In these conditions, soybean crops are well characterized in remote sensing images, standing out from other land use classes such as bare soil or vegetation having different phenology.

The mapping of soybean spatial distribution was performed by analyzing the 12 Landsat images in following steps. First, ENVI 4.2 software was used to georeference the images based on RGB color composites (using channels 4, 5, 3 respectively). Then, a mixture model described by Shimabukuro and Smith, (1991) was used to represent sample targets of green vegetation (soybeans in this case), soil, and shade. Fifty-pixel samples were chosen for the test, as described in the procedure described by Rizzi and Rudorff (2005). The next step consisted of using a segmentation approach of growing "regions", where a "region" is a set of homogeneous pixels grouped according to their spectral and spatial properties. An unsupervised classification based on a 'clustering' algorithm, named ISOSEG (Rizzi *et al.*, 2006), was applied to the segmented image. In order to correct errors resulting from the digital classification described above, a visual interpretation was performed in all images. A direct expansion estimator and a semi-automated procedure as suggested by Adami *et al.* (2007) were used to generate a grid with regular pixel size of 250m by 250m.

Finally, different samples of NDVI were obtained from the Terra MODIS sensor (MOD13Q1 product version 5, 16-day image composite) in the region representing "pure-pixels" of soybean, i.e., pixels with soybean crops only (identified using Landsat images as described above). The pixels were extracted using the IRI Data Library (*International Research Institute for Climate and Society*) and NASA (*National Aeronautics and Space Administration – EOS*), for the 2000 - 2007 period.

3. Results

The different phenological stages of soybeans were identified with the NDVI time series from 2000 to 2007 for each location (Figure 1). Growth starts around mid November and the cycle ends in March when the soybean is harvested. A similar pattern was observed for all crop years and locations indicating that the pixels selected for the analysis were indeed soybean pure-pixels. In 2004/2005 a drop in NDVI values was observed in the Cerro Azul and Ponta Grossa locations.

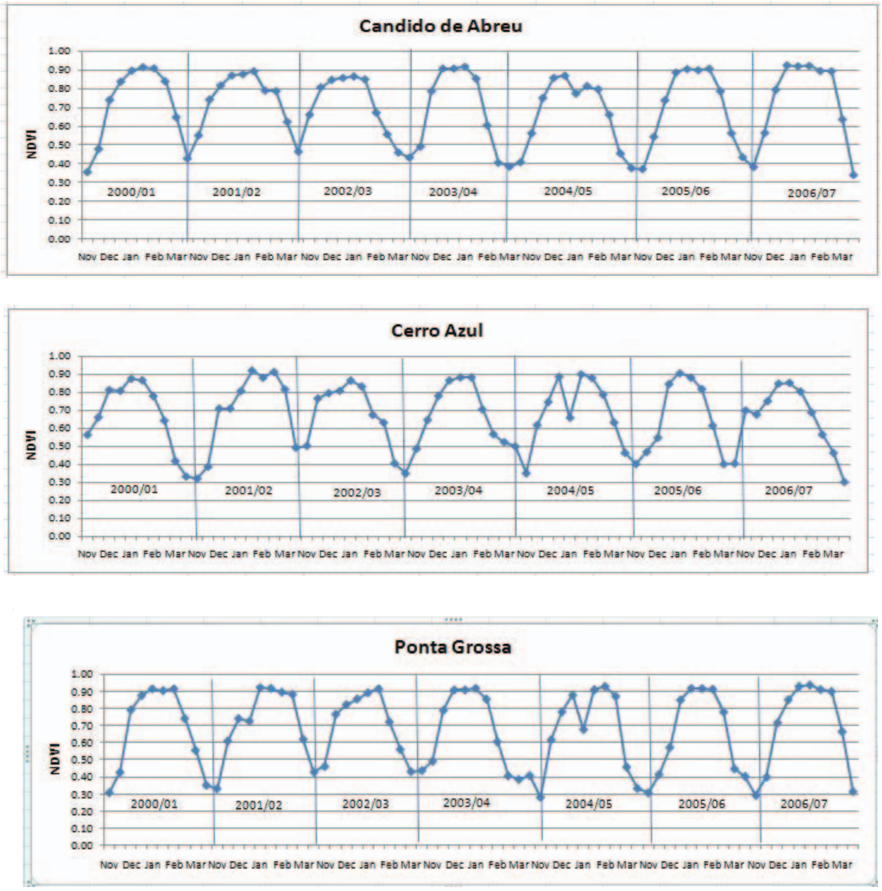

Figure 1. NDVI temporal series from 2000 to 2007 for each study locations.

A comparison with rainfall values for these locations (Figure 2), showed that rainfall was low in January and mid February, which coincides with the peak of the reproductive stage of soybean in the study region. This observation was reported by CONAB (2005) which mention a 7.1% yield loss in relation to the previous year yields, in the state of Parana. A reduction of NDVI values could also be caused by the presence of clouds. Then in order to ensure that this was not the case, we inspected visually these pixels.

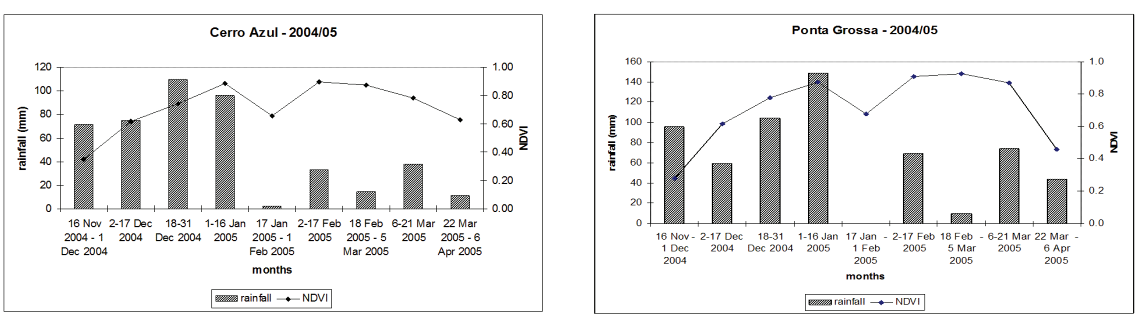

Figure 2. Rainfall and NDVI values for Cerro Azul and Ponta Grossa locations during 2004/05. (Note the low rainfall values during Jan-Feb 2005 that resulted in a decrease of NDVI values).

Figure 3 displays an example of soybean NDVI values during Jan-Feb 2005 confirming that the low NDVI values were not influenced by cloud cover.

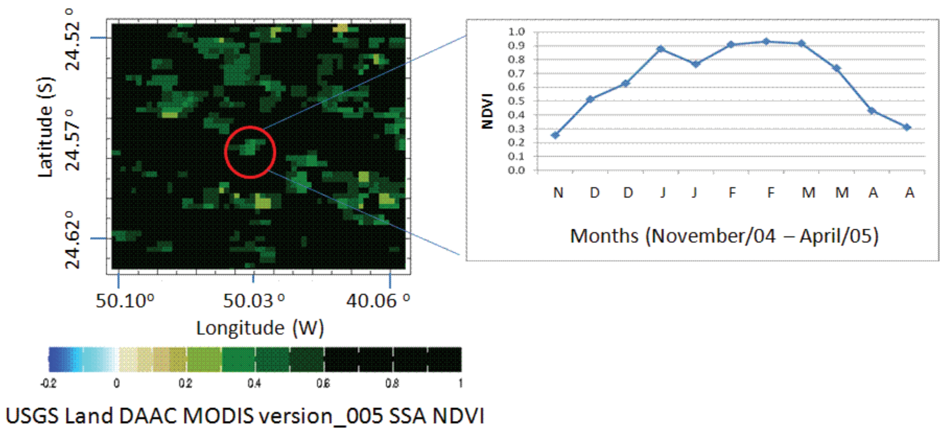

Figure 3. NDVI values of soybean during Jan-Feb 2005. Pixel coordinates: 50.01794W; 24.58271S.

4. Conclusions

NDVI values adequately described the soybean phenology, showing soybean growing curves for all locations in the state of Parana, Brazil. Analysis of the evolution of NDVI values allowed to identifying the soybean growing season (November to March) and the dry season for this region.

5. Acknowledgements

The first author would like to thank IRI-Columbia University for all contributions made to this study.

6. References

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