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Wavelet analysis of MODIS time series to detect expansion and intensification of row-crop agriculture in Brazil

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Abstract

Since 2000, the southwestern Brazilian Amazon has undergone a rapid transformation from natural vegetation and pastures to row-crop agricultural with the potential to affect regional biogeochemistry. The goals of this research are to assess wavelet algorithms applied to MODIS time series to determine expansion of row-crops and intensification of the number of crops grown. MODIS provides data from February 2000 to present, a period of agricultural expansion and intensification in the southwestern Brazilian Amazon. We have selected a study area near Comodoro, Mato Grosso because of the rapid growth of row-crop agriculture and availability of ground truth data of agricultural land-use history. We used a 90% power wavelet transform to create a wavelet-smoothed time series for five years of MODIS EVI data. From this wavelet-smoothed time series we determine characteristic phenology of single and double crops. We estimate that over 3200 km^2 were converted from native vegetation and pasture to row-crop agriculture from 2000 to 2005 in our study area encompassing 40,000 km^2. We observe an increase of 2000 km^2 of agricultural intensification, where areas of single crops were converted to double crops during the study period.

Keywords: MODIS; EVI; Time-series analysis; Wavelet analysis; Land use and land cover change; Croplands and crop detection; Row-crop agriculture; Land use in the Brazilian Amazon

1. Introduction

The southwestern Brazilian Amazon is one of the world's fastest growing agricultural frontiers. Historically, the clearing of forest and savanna ecosystems to create cattle pastures has been the primary land transformation (Skole & Tucker, 1993). This land-use pattern has recently changed. Today, pastures and areas of natural vegetation are being converted to large-scale croplands to grow cash crops, row crops including soybean, maize, and dry-land rice (Instituto Brasileiro de Geografia e Estatistica, 2006; Morton et al., 2006). From 1990 to 2000, soybean cover in the southwestern Brazilian Amazon doubled while production has nearly quadrupled due to farm mechanization (CONAB, 2004). A major frontier of row crops is in the state of Mato Grosso, home of some of the largest contiguous row-crop plantations in the world. Here, the area planted in soybean has increased on average 19.4% annually since 1999. By 2004 over 5 million hectares, or about 6% of Mato Grosso, was soybean plantations (CONAB, 2004).

Regional shifts in land-cover and land-use have numerous consequences relevant to both environment and agriculture, including changes in carbon and nitrogen storage, trace gas emissions, quality of surface water and biodiversity (Luizão et al., 1989; Melillo et al., 1996, 2001; Myers et al., 2000; Neill et al., 1997, 2001; Steudler et al., 1996). Determining the physical and temporal patterns of agricultural extensitificaiton, or expansion, and intensification is the first step in understanding their implications, for example, long-term crop production, and environmental, agricultural and economic sustainability.

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