frequency noise caused by the frequent cloud-cover in a highly automated way.

MODIS data products offer a great opportunity for phenology-based land-cover and land-use change studies by combining characteristics of AVHRR and Landsat, including: moderate spatial resolution, frequent observations, enhanced spectral resolution and improved atmospheric calibration (Justice, 1998; Zhang et al., 2003). MODIS data products have provided global land-cover mapping annually to document land-cover change over time (Friedl et al., 2002; Hansen & DeFries, 2004). These data sets are informative at the global level, but lack relevant regional-scale details about land-cover and land-use classes and change. Recent regional-scale applications of MODIS data to cropland land-use include spectral unmixing to time series to detect subpixel land-cover in croplands (Lobell & Asner, 2004). Wardlow et al. (2007) demonstrate that MODIS vegetation indices in time series are statistically sufficient for distinguishing crop types across a broad region, such as the state of Kansas. In the Amazon, Anderson et al. (2005) have utilized MODIS data sets to document broad changes in land cover and land use.

Understanding the degree of extensification and intensification in croplands from remote sensing provides insight into the direction and magnitude of impacts on natural and agricultural environments. In the industrial-scale croplands that are beginning to dominate portions of the Amazon Basin, patterns of cropland extensification and intensification have biogeochemical consequences that affect the natural and cropland sustainability, including soil fertility for decades to come. *Our objective is two-fold: to understand 1) the massive transition from natural vegetation and pasture to large-scale row crops and 2) the intensification of cropping systems within existing croplands using MODIS data sets*. The purpose of this study is to detect cropping patterns for the *cerrado* region using a wavelet-smoothed time series. This study evaluates wavelet tools, as presented by Sakamoto et al. (2005), in a new environment and tests the limits of the wavelet model while modeling crop phenologies from MODIS time-series data during the 2001–2006 growing seasons. We provide analysis and discussion of the effectiveness of wavelet analysis for the detection of single and double cropping systems and hereby demonstrate the utility of wavelet analysis on time-series data with application to a land-use and land-cover change case study in the southwestern Brazilian Amazon.

2. Methods and approach

An overview of the methodology used here is presented in Fig. 1. The general methodology is based on the "Wavelet based Filter for Crop Phenology" (WFCP, Sakamoto et al., 2005). There are four main steps: 1) Data processing, 2) Identification of land use, 3) Field verification and 4) Error Analysis.

2.1. Study area

We selected a region of rapid change in croplands in the state of Mato Grosso for this study (Upper left corner: 12° 15′ 23.61″ S, 59° 45′ 18.23″ W; Lower right corner: 13° 59′ 27.86″ S, 57°57′ 30.8″ W; Figs. 2, 3). The area is 40,100 km^2, has annual rainfall from 1800 to 2200 mm, and a dry season from July–September and rainy (growing) season from November to April. The soils are entisols with 15–25% clay. Dominant native vegetation types range from *cerradão* (woody savanna) and *cerrado* (open savanna), referred to from here forward as "cerrado". In this region, land-use transitions have two major pathways to row crops from *cerrado*: natural vegetation to pasture to row crops; and natural vegetation directly to row crops. Row crops are subject to a variety of management regimes—types and sequences of crops; types, timing and amounts of fertilizer and other chemicals; and tillage versus no-tillage.

2.2. Field data

Field work conducted in July 2005 provided ground-control points on a *fazenda* of 41 km^2 for which a detailed agricultural

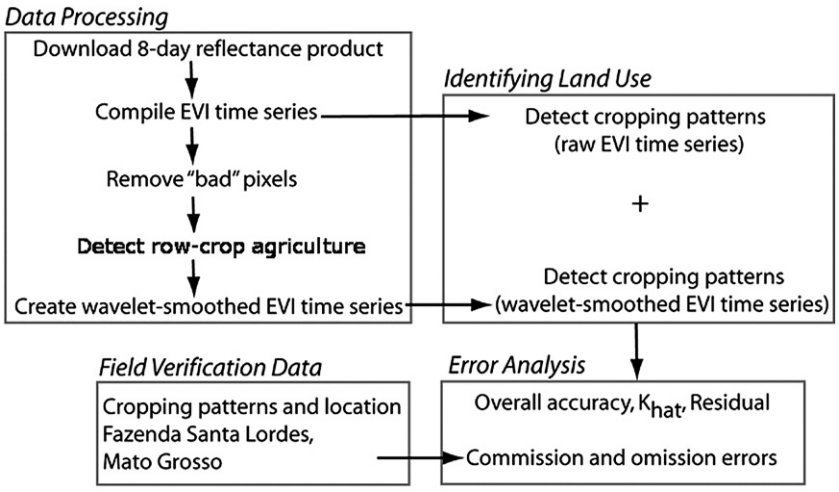

Fig. 1. Overview of methodology, divided into four parts: data processing, crop detection, field verification data and error analysis.