



MundoGEO#Connect LatinAmerica 2012  
29 a 31 de maio, São Paulo-SP, Brasil

"Compartilhar informações para um mundo melhor"

## Seminário Imagens de Satélite

"Imagens como apoio ao agronegócio"

***Desafios e resultados da aplicação de sensores orbitais nas áreas de agricultura e florestas***

**Bernardo Rudorff**



**Instituto Nacional de Pesquisas Espaciais – INPE**



**Divisão de Sensoriamento Remoto**



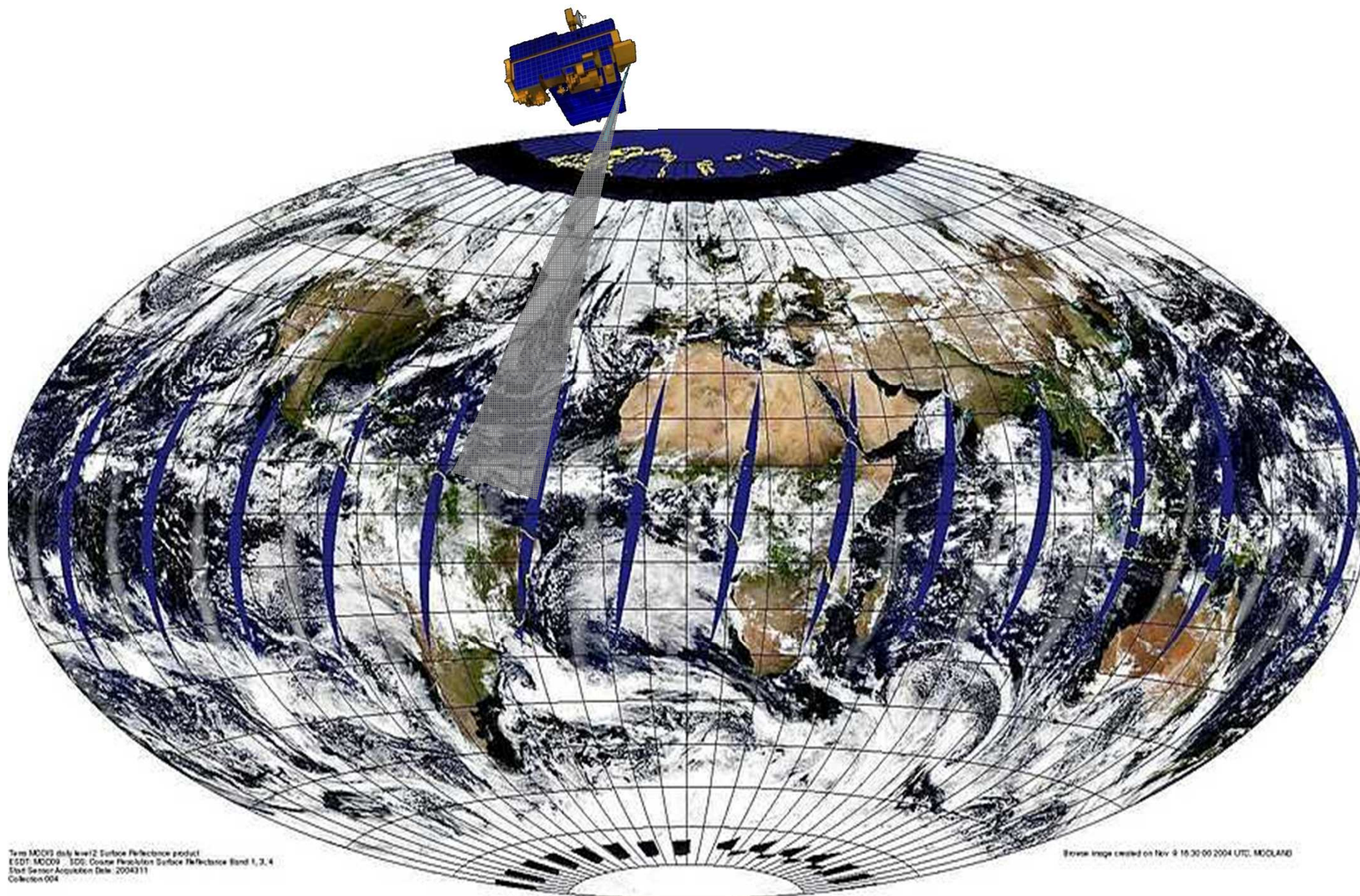
**Laboratório de Sensoriamento Remoto em Agricultura e Floresta – LAF**

# ***Desafios da aplicação de sensores orbitais nas áreas de agricultura e florestas***

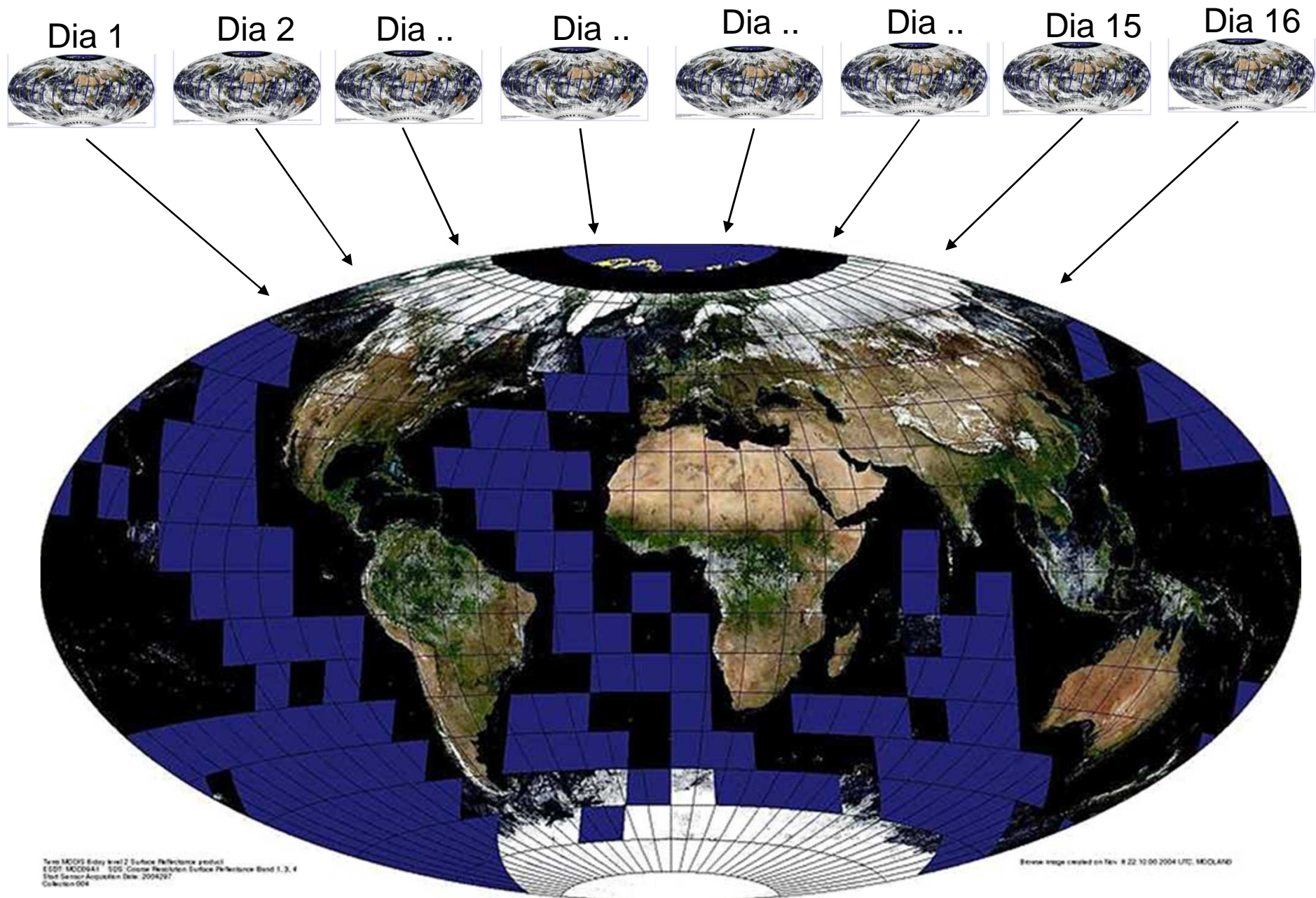
- 1) Satélites/sensores:** resoluções espacial, **temporal**, espectral, radiométrica;
- 2) Infraestrutura de aquisição e distribuição:** recepção de dados, política de distribuição, geração de produtos, continuidade, regularidade, armazenamento;
- 3) Análise dos dados:** visual, digital, formação de pessoal, volume de dados, escala, confiabilidade;
- 4) Interesses do agronegócio:** informação estratégica, transparência, objetividade;
- 5) Outros:** potencial, limitação, frustração, complexidade, ...

# Resolução Temporal

# Satélite Terra - Sensor MODIS



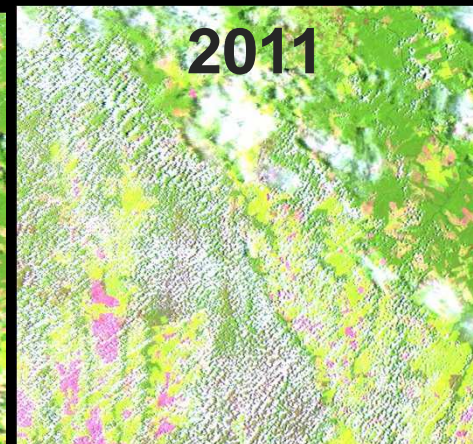
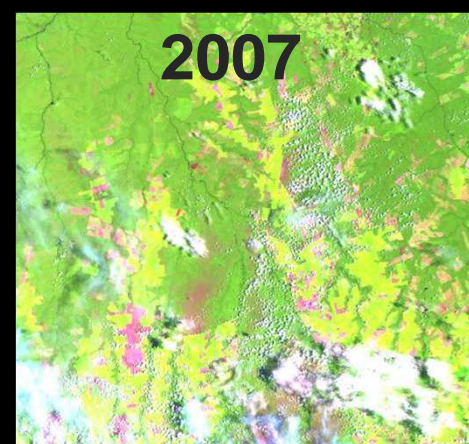
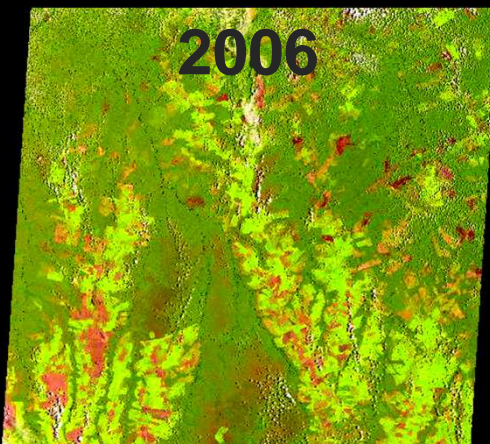
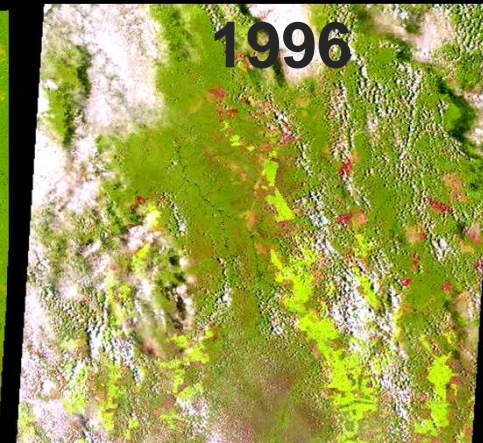
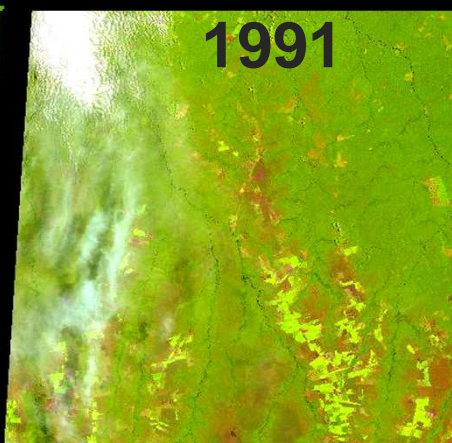
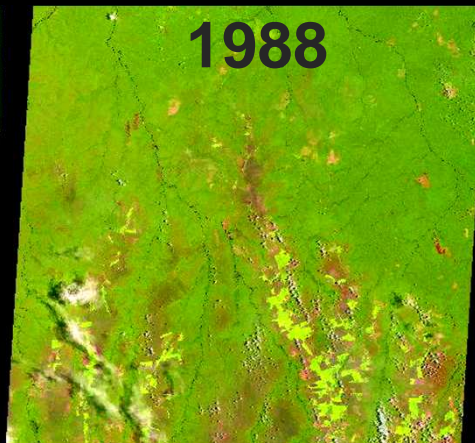
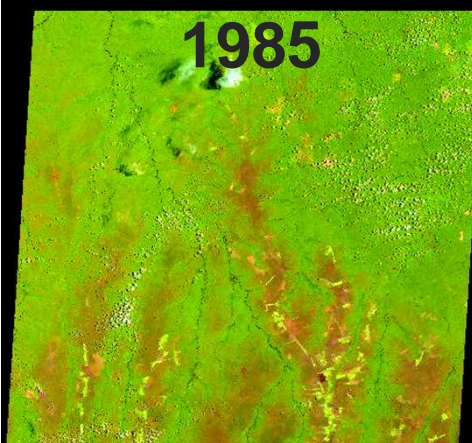
# Imagem - Composição para eliminação de nuvens















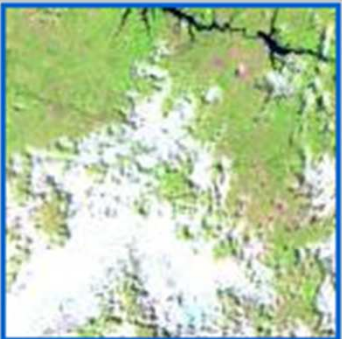












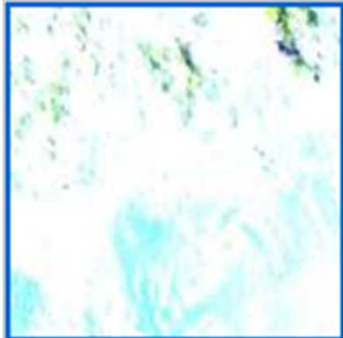










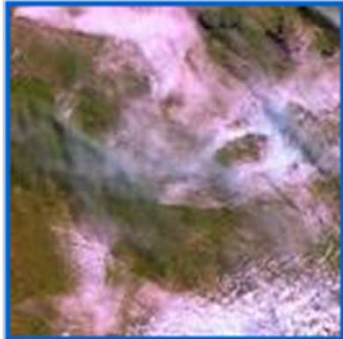




Composição de 16 dias de imagens diárias da 1ª quinzena de janeiro 2002  
*MODIS* 5(SWIR), 2(NIR), 1(R)

**Imagens do Landsat-5 (228/69) “livres de nuvens” de uma região do Mato Grosso para os meses de janeiro e fevereiro de 1985 a 2012 - SOJA (1 imagem a cada 3 anos)**













































# Imagens disponíveis do Landsat-5 (222/75) de 01/09/2009 a 30/04/2010 (CANA)












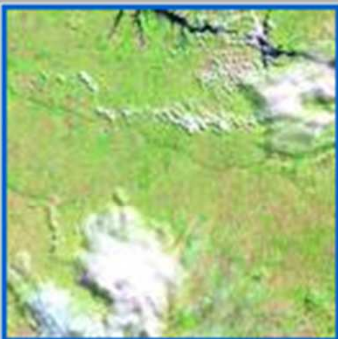


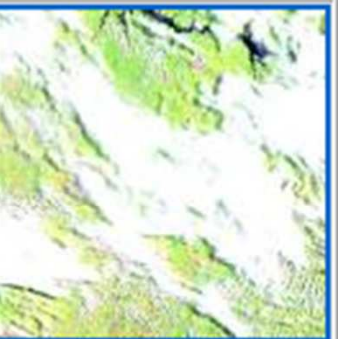












L5TM 222/75-2010-04-23	L5TM 222/75-2010-04-07	L5TM 222/75-2010-03-22	L5TM 222/75-2010-02-18	L5TM 222/75-2010-02-02
 	 	 	 	 
				
L5TM 222/75-2010-01-17	L5TM 222/75-2009-12-16	L5TM 222/75-2009-11-30	L5TM 222/75-2009-11-14	L5TM 222/75-2009-10-29
 	 	 	 	 
				
L5TM 222/75-2009-10-13	L5TM 222/75-2009-09-27	L5TM 222/75-2009-09-11		
 	 	 		
				



## Imagens disponíveis do Landsat-5 (222/75) de 01/09/2008 a 30/04/2009 (CANA)

L5TM 222/75-2009-04-20	L5TM 222/75-2009-04-04	L5TM 222/75-2009-03-19	L5TM 222/75-2009-03-03	L5TM 222/75-2009-02-15
 	 	 	 	 
				
L5TM 222/75-2009-01-30	L5TM 222/75-2009-01-14	L5TM 222/75-2008-12-13	L5TM 222/75-2008-11-27	L5TM 222/75-2008-11-11
 	 	 	 	 
				
L5TM 222/75-2008-10-26	L5TM 222/75-2008-10-10	L5TM 222/75-2008-09-24	L5TM 222/75-2008-09-08	
 	 	 	 	
				

## Imagens disponíveis do Landsat-5 (222/75) de 01/09/2007 a 30/04/2008 (CANA)

L5TM 222/75-2008-04-17	L5TM 222/75-2008-04-01	L5TM 222/75-2008-03-16	L5TM 222/75-2008-02-29	L5TM 222/75-2008-02-13
 	 	 	 	 
				
L5TM 222/75-2008-01-28	L5TM 222/75-2008-01-12	L5TM 222/75-2007-09-22	L5TM 222/75-2007-09-06	
 	 	 	 	
				

***Resultados da aplicação de sensores orbitais  
na área de agricultura***



# **Projeto Canasat**

## **Monitoramento da cana-de-açúcar para fins de sustentabilidade da produção de etanol**

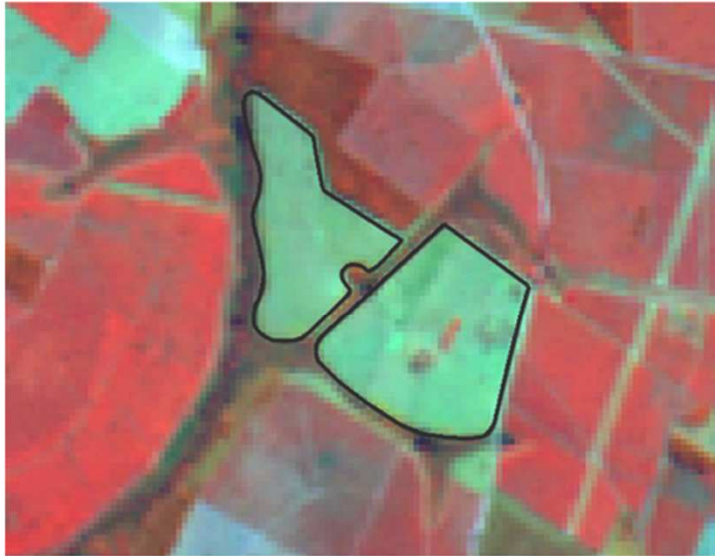
- 1. Mapeamento e Previsão da Área Cultivada**
- 2. Monitoramento da Prática da Colheita**
- 3. Mudança de Uso da Terra**
- 4. Séries Temporais MODIS**

# Mapeamento e Previsão da Área Cultivada



- **90% da cana do Brasil é cultivada na região Centro-sul;**
- **Esta região tem grande potencial de expansão – entre 2003 e 2011 a área de cana foi de 4.3 Mha para 8.6 Mha**

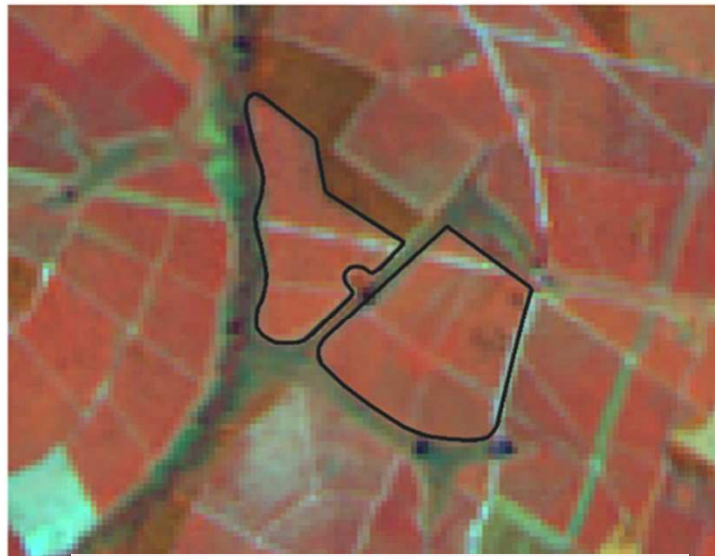
## Mapeamento da Expansão – novas áreas de cana



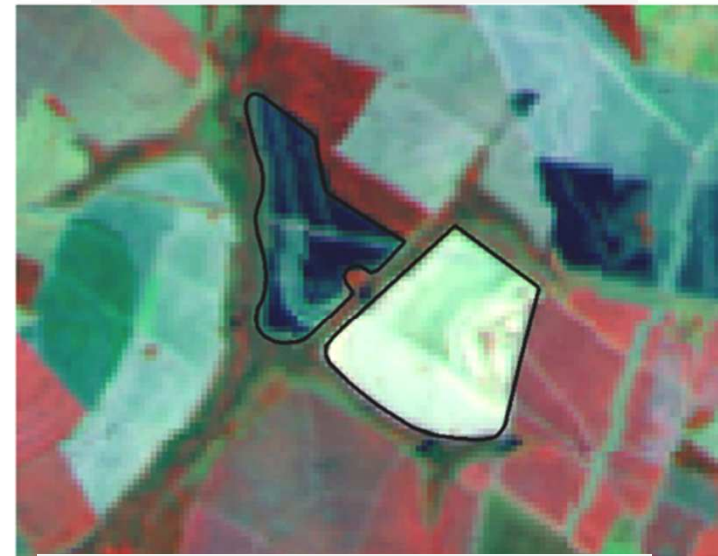
24 abril, 2007



11 junho, 2007

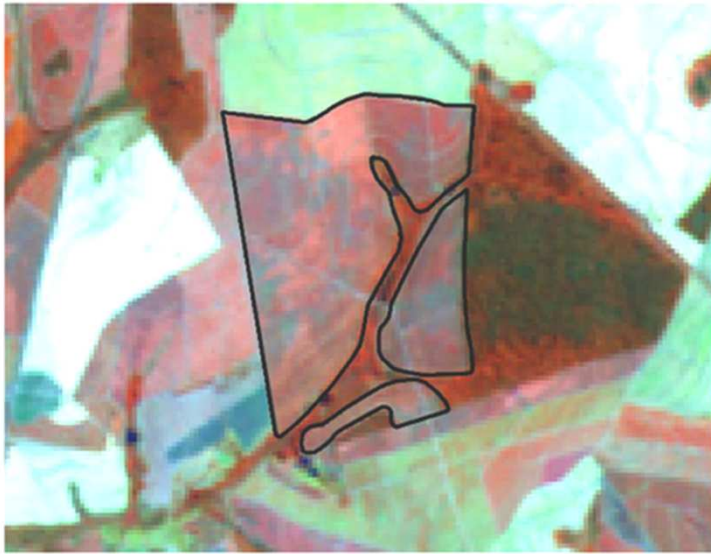


25 março, 2008

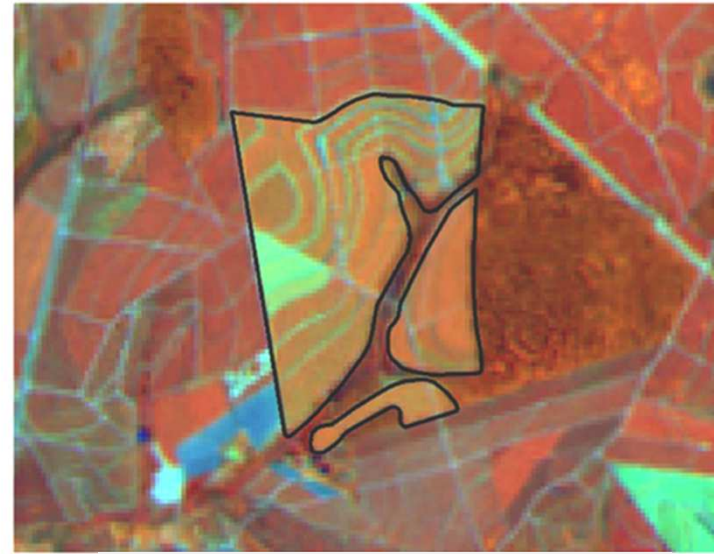


17 setembro, 2008

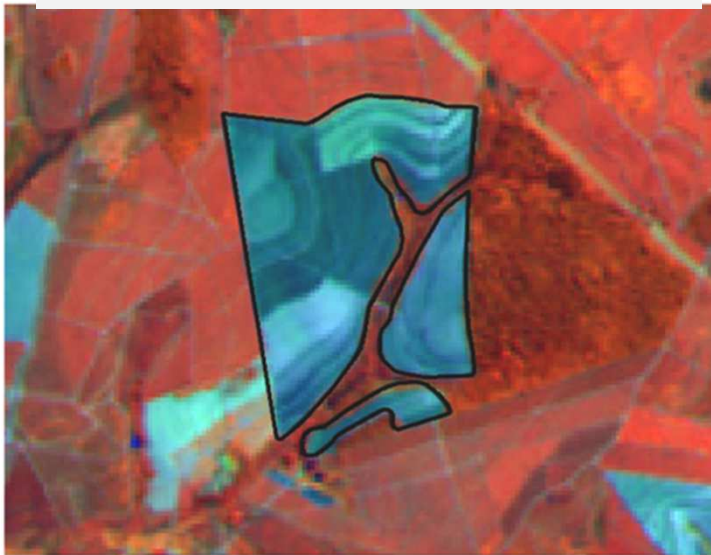
## Mapeamento da Renovação – Cana de Ano e Meio



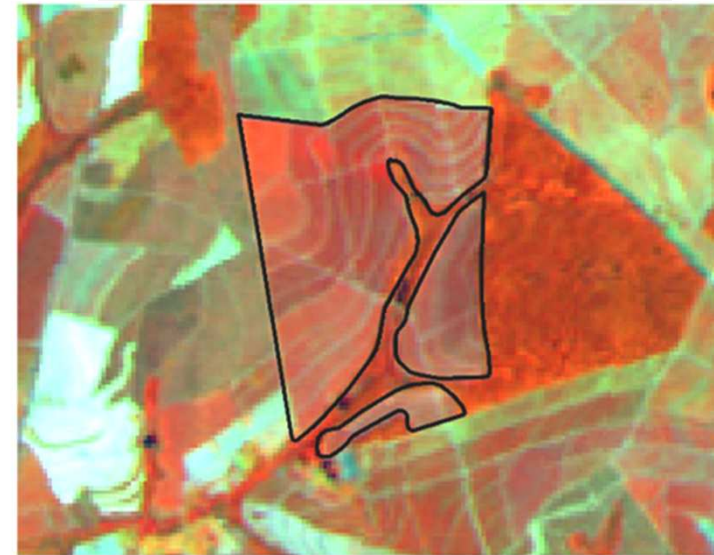
15 setembro, 2007



25 março, 2008



26 abril, 2008

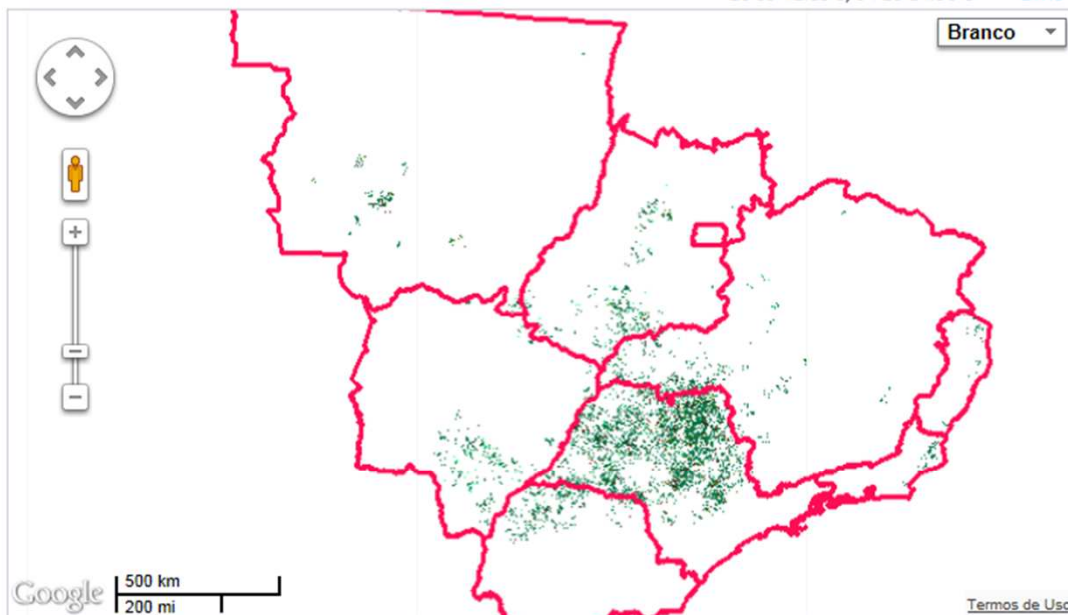


06 dezembro, 2007



20 09 42.85 S, 54 23 14.56 O **GMS**

Branco



Camadas do mapa

- Estados
- Municípios
- Safra 2011**
- Safra 2010
- Safra 2009
- Safra 2008
- Safra 2007
- Safra 2006
- Safra 2005

Legenda

- CS
- soca
- reformada
- expansão
- em reforma

realização



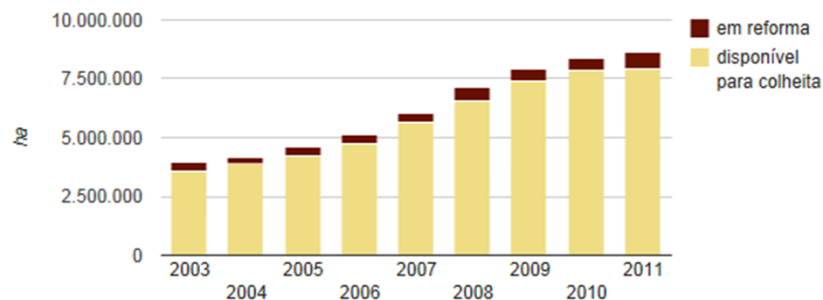
apoio



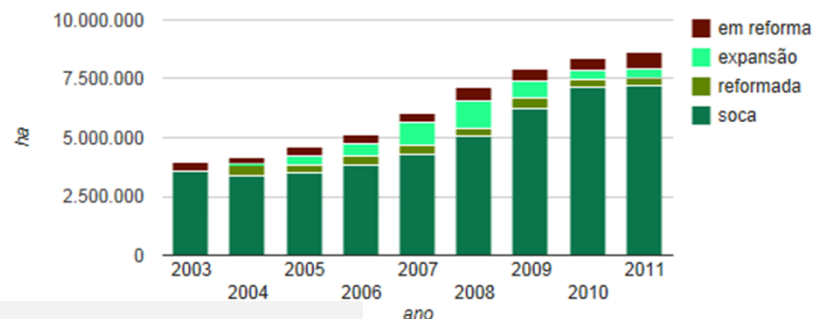
Exibir dados do município de  **ir** ou do estado de **Centro-sul** **ir**

### Dados da Região Centro-sul

Área disponível para colheita e em reforma



Área cultivada com cana por classe



<http://www.dsr.inpe.br/laf/canasat/>



realização

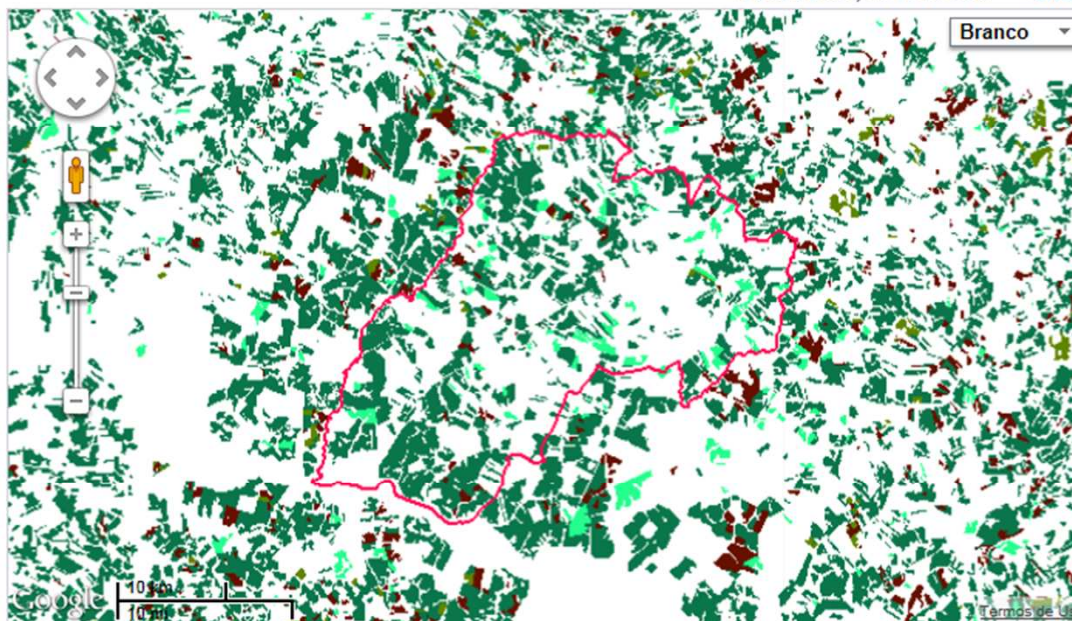


apoio



21 20 04.98 S, 49 37 41.25 O [GMS](#)

Branco



Camadas do mapa

- Estados
- Municípios
- Safra 2011
- Safra 2010
- Safra 2009
- Safra 2008
- Safra 2007
- Safra 2006
- Safra 2005

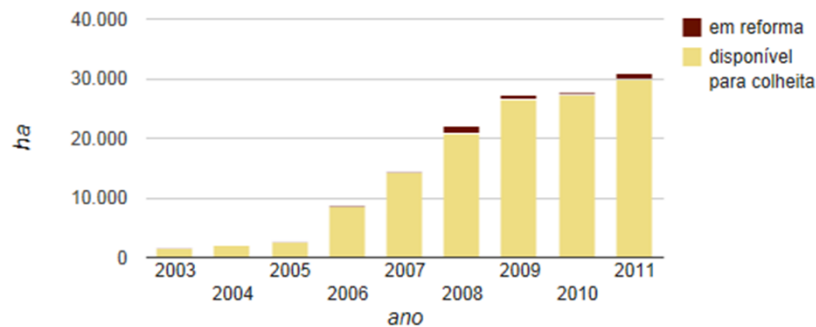
Legenda

- ✓ José Bonifácio - SP
- soca
- reformada
- expansão
- em reforma

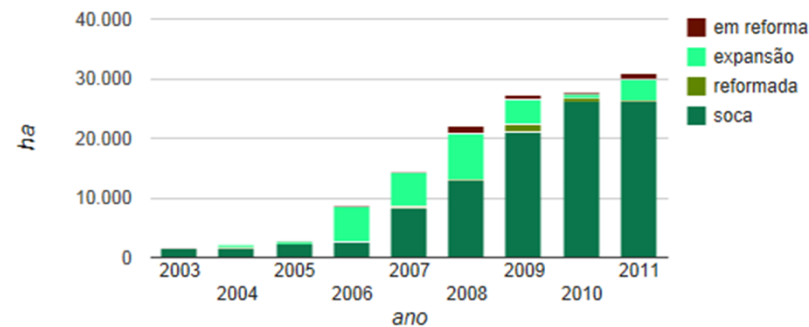
Exibir dados do município de   ou do estado de

### Dados do município de José Bonifácio - SP

Área disponível para colheita e em reforma

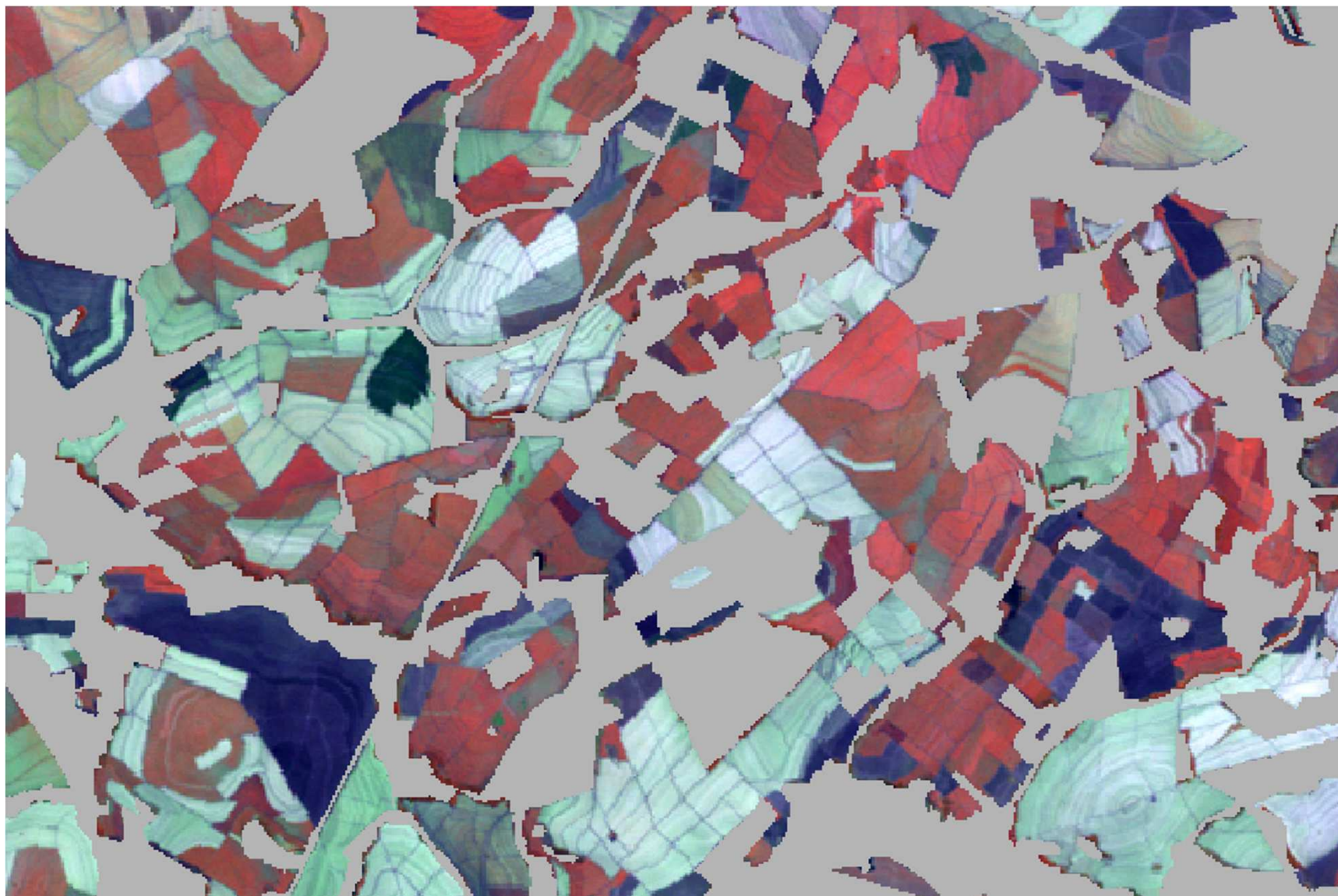


Área cultivada com cana por classe



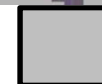


Colheita sem queima e Colheita com queima

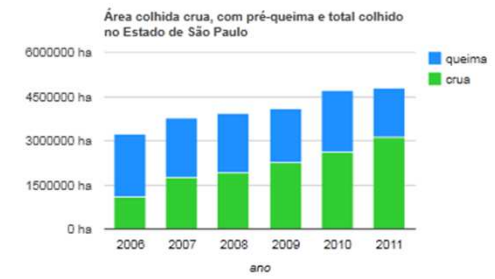
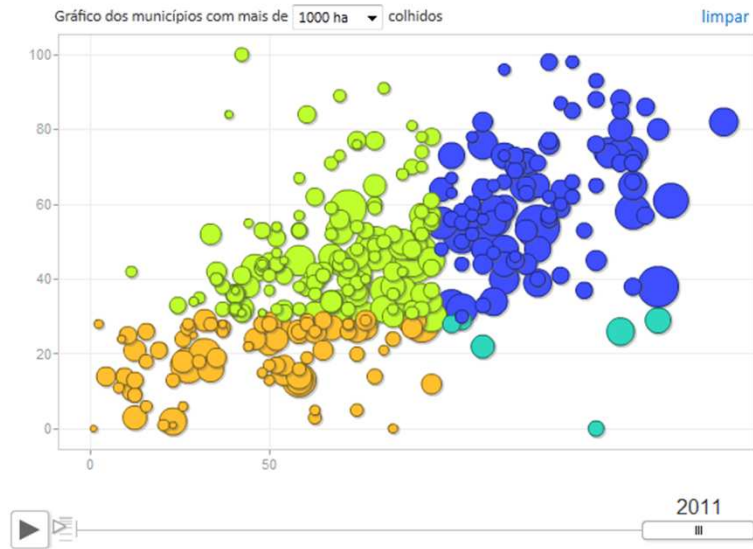
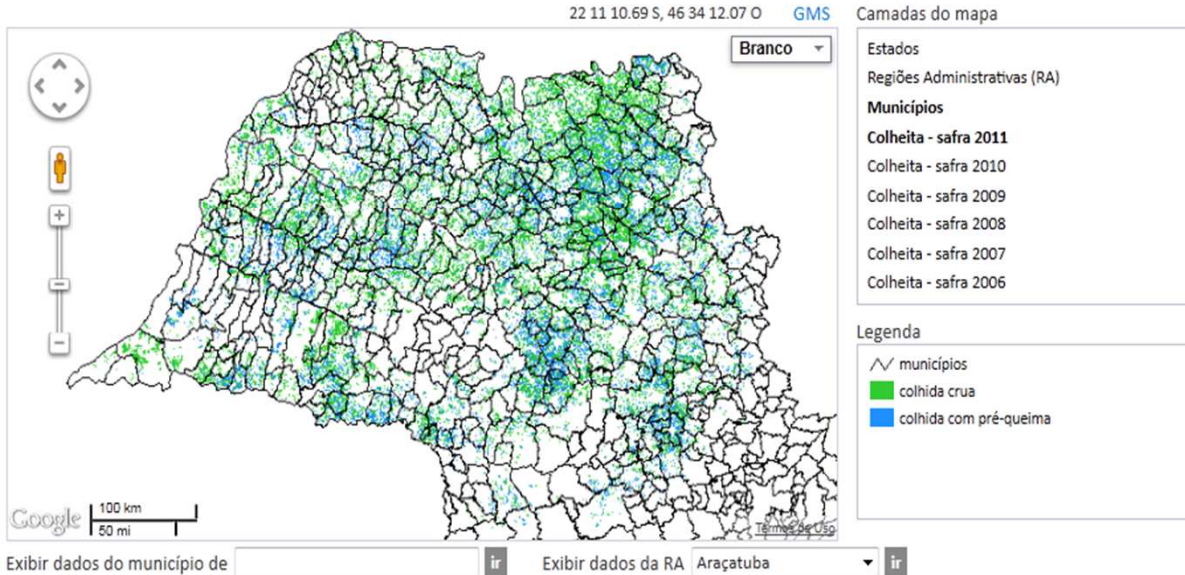


Landsat-5

18 Agosto 2011



Outros usos



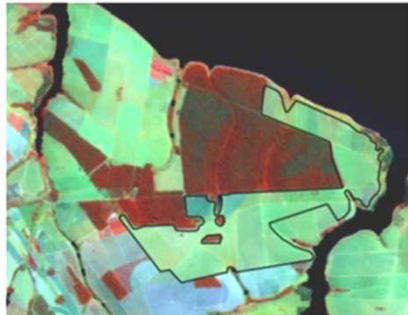
Área colhida crua, com pré-queima e total colhido no Estado de São Paulo

ano	crua (ha)	crua (%)	pré-queima (ha)	pré-queima (%)	total (ha)
2006	1.110.120	34.2	2.131.990	65.8	3.242.110
2007	1.764.992	46.6	2.025.448	53.4	3.790.440
2008	1.924.075	49.1	1.997.630	50.9	3.921.705
2009	2.266.403	55.6	1.810.531	44.4	4.076.934
2010	2.627.025	55.6	2.101.110	44.4	4.728.135
2011	3.125.619	65.2	1.670.521	34.8	4.796.140

Aguiar, D.A.; Rudorff, B.F.T.; Silva, W.F.; Adami, M.; Mello, M.P. Remote Sensing Images in Support of Environmental Protocol: Monitoring the Sugarcane Harvest in São Paulo State, Brazil. *Remote Sens.* **2011**, *3*, 2682-2703.

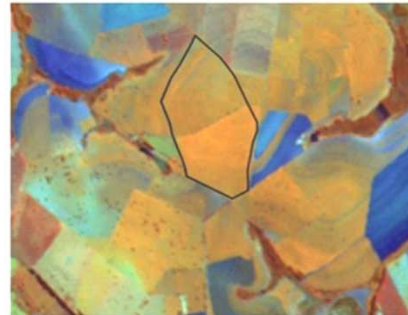
# Mudança de Uso da Terra

Pasto



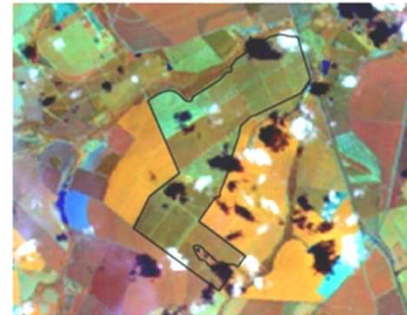
6a) 12/09/06

Soja



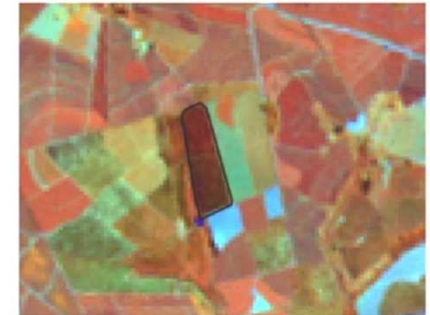
7a) 21/04/06

Citros

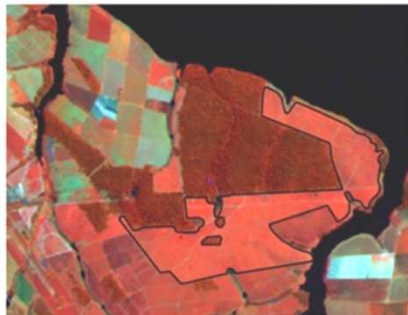


8a) 04/03/06

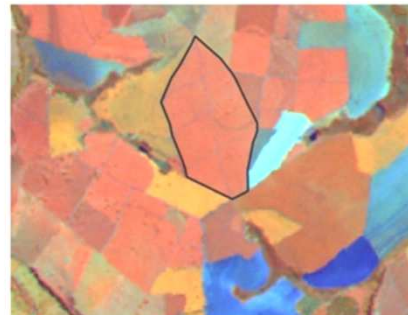
Vegetação Arbórea



9a) 21/04/06



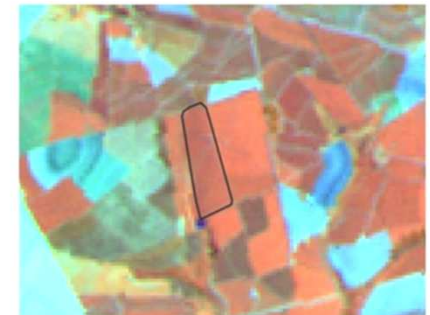
6b) 26/04/08



7b) 26/04/08

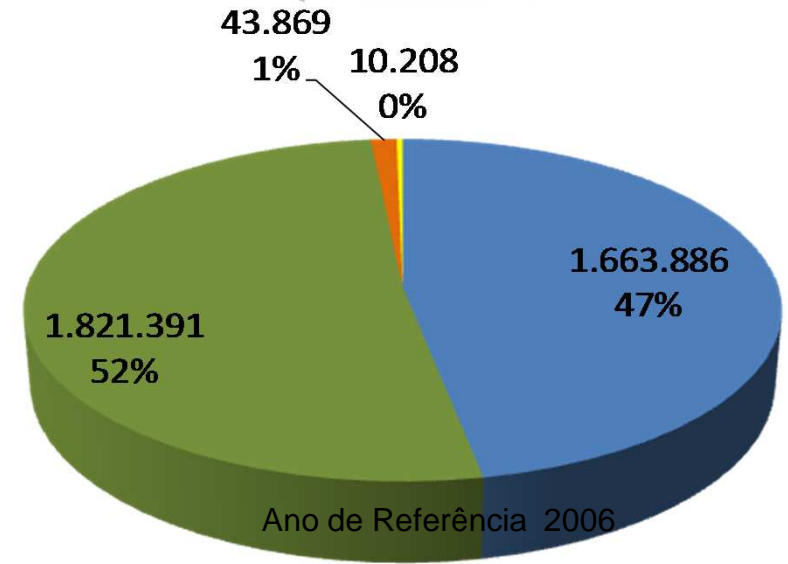
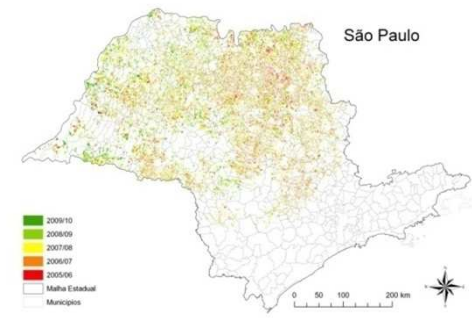
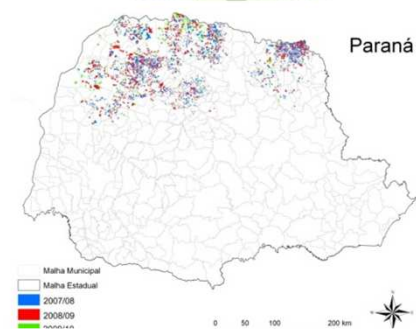
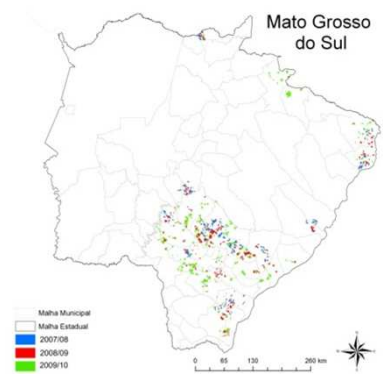
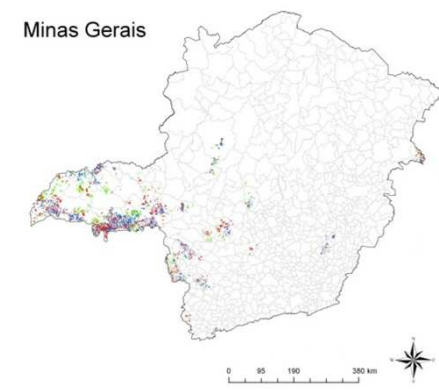
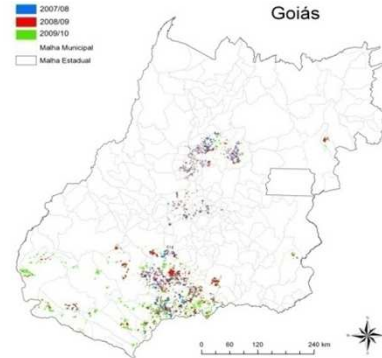
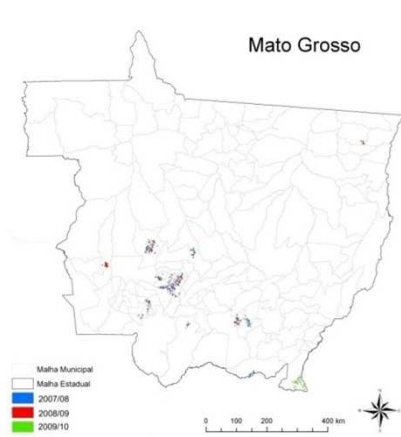


8b) 26/04/08



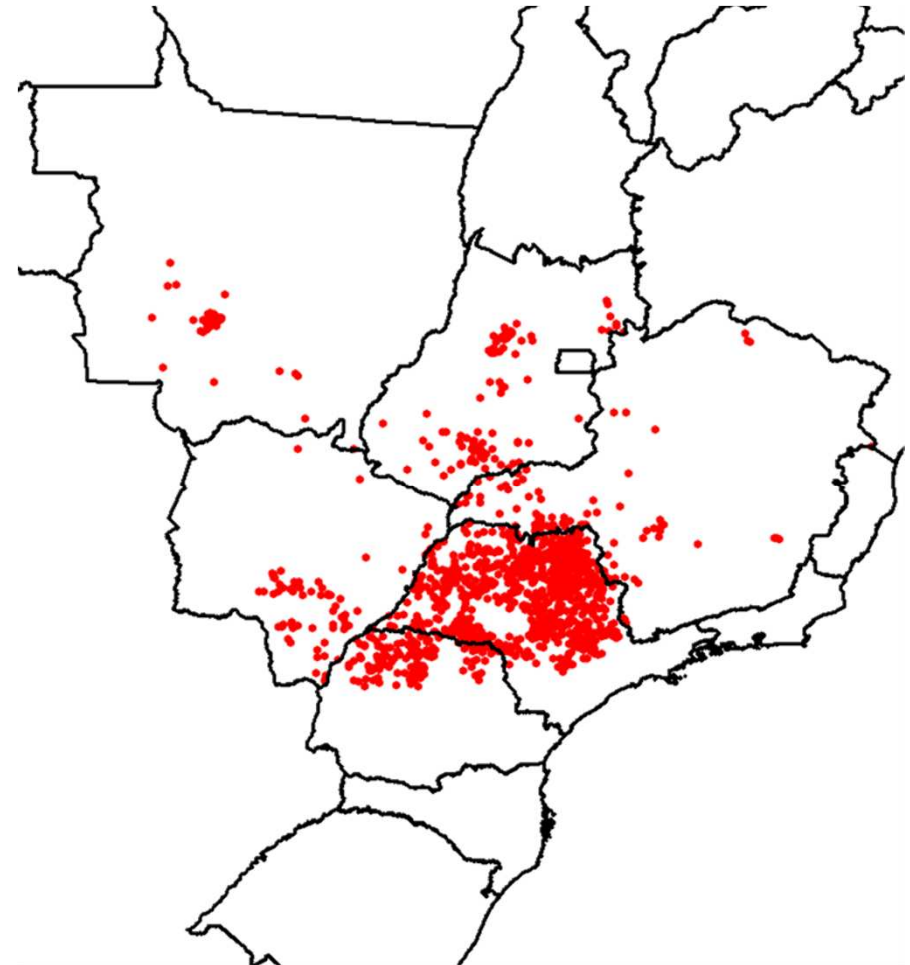
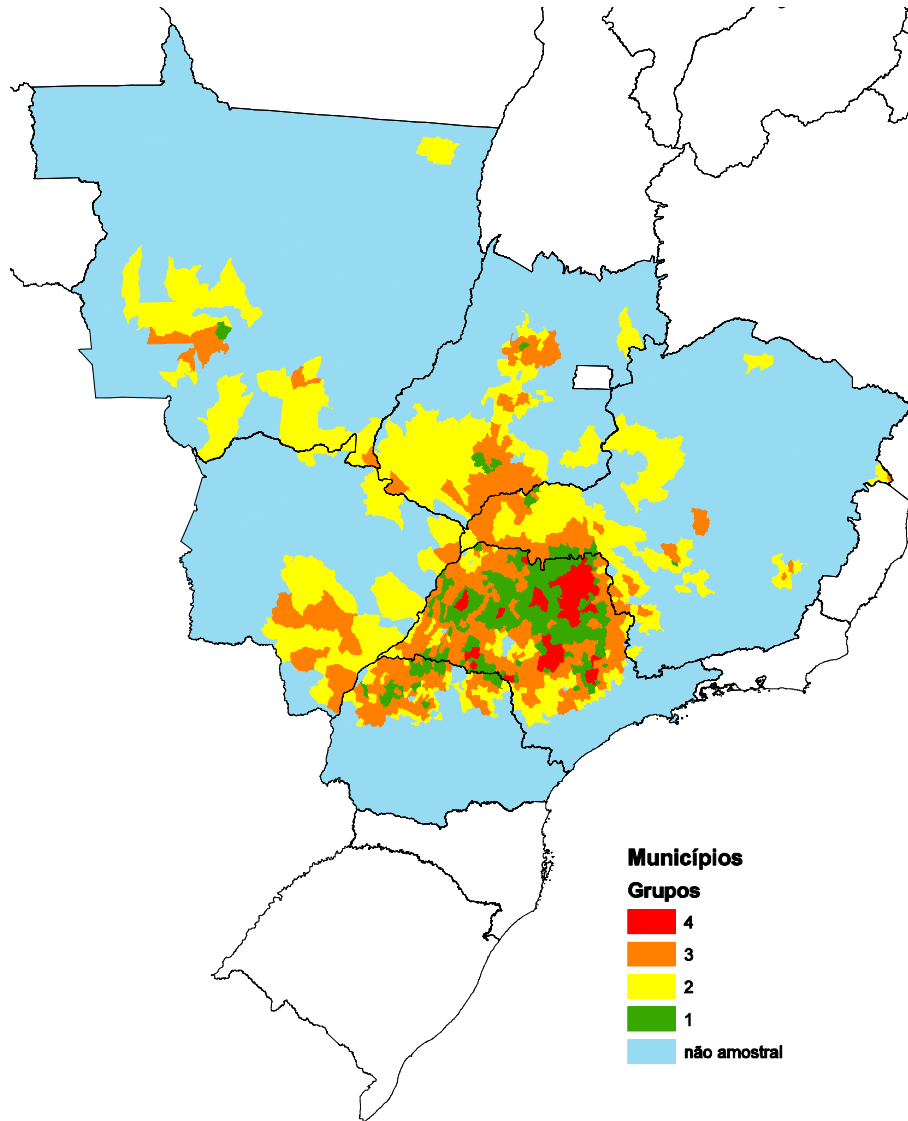
9b) 26/04/08

# Mudança de uso da Terra causado pela expansão da cana de 2006/07 a 2009/10



- Agricola
- Pastagem
- Citrus
- Vegetação Arbórea

# Validação do Mapeamento



Distribuição das amostras: 1504 pontos

# Plataforma web para avaliação da acurácia do mapeamento da cana

http://www.dsr.inpe.br/laf/validamapacana/class.php

Mais visitados | Primeiros passos | Últimas notícias

LAF-INPE

Laboratório de Agricultura e Floresta do INPE

DSR INPE

## Validação do mapa de cana-de-açúcar 2009/10

Sair

Satélite -23.1447, -51.8972 Local  Ir

**Imagens**

27/09/2009 29/10/2009 02/02/2010 **07/04/2010** 02/06/2010  
26/06/2010 12/07/2010

**Pontos**

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	<b>45</b>	46	47	48	49

Dados cartográficos ©2011 MapLink Imagens ©2011 Cnes/Spot Image, DigitalGlobe, GeoEye - Termos de Uso

5d 1m 3m 6m 1y Max

• EVI2 original: 0,518 • EVI2 filtrada: 0,478 | 17/12/2009

**Ponto 45**

Cana  sim  não

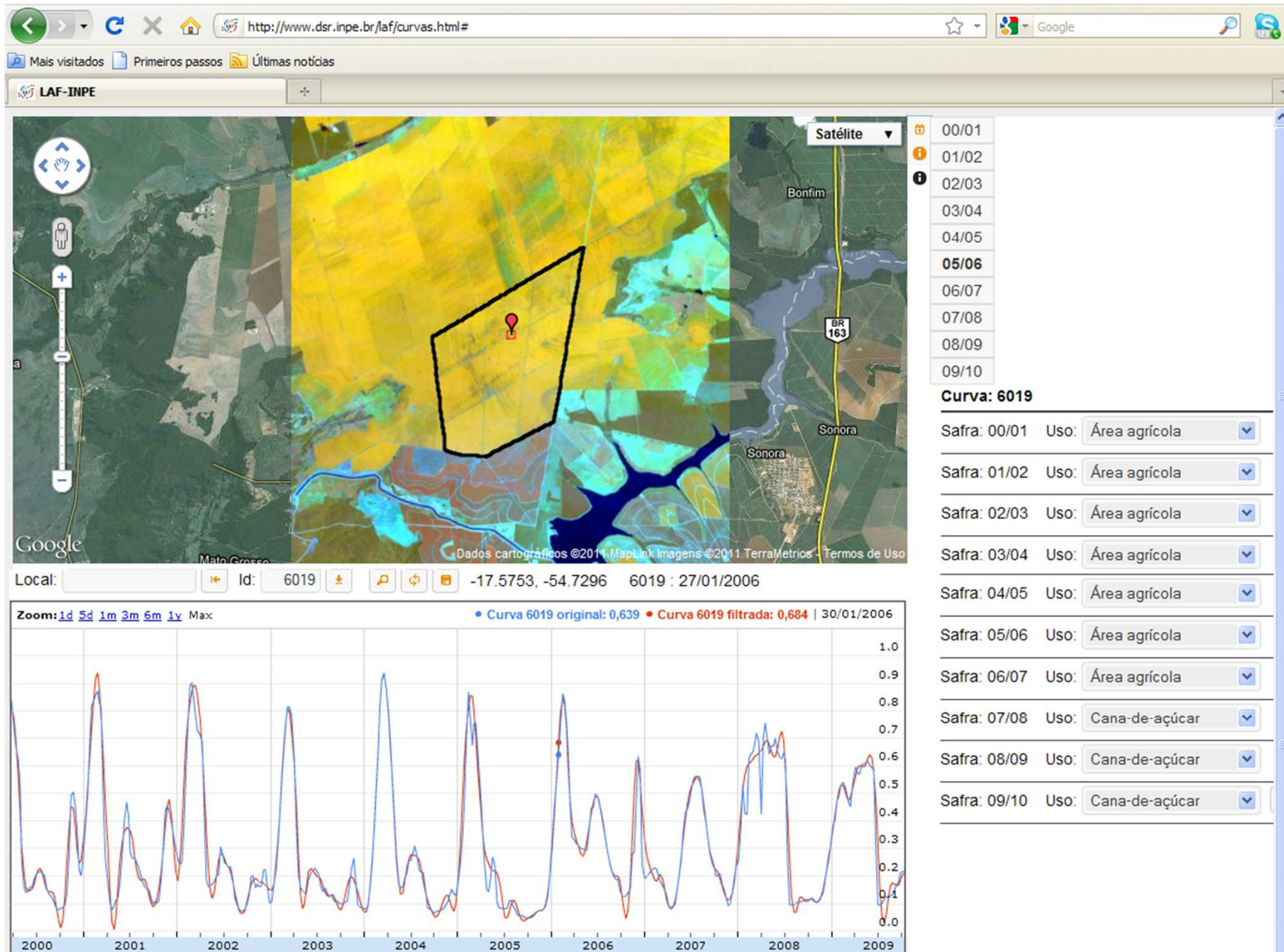
**Salvar** **Remover**

2001 2002 2003 2004 2005 2006 2007 2008 2009

**Acurácia Geral**  
**98%**

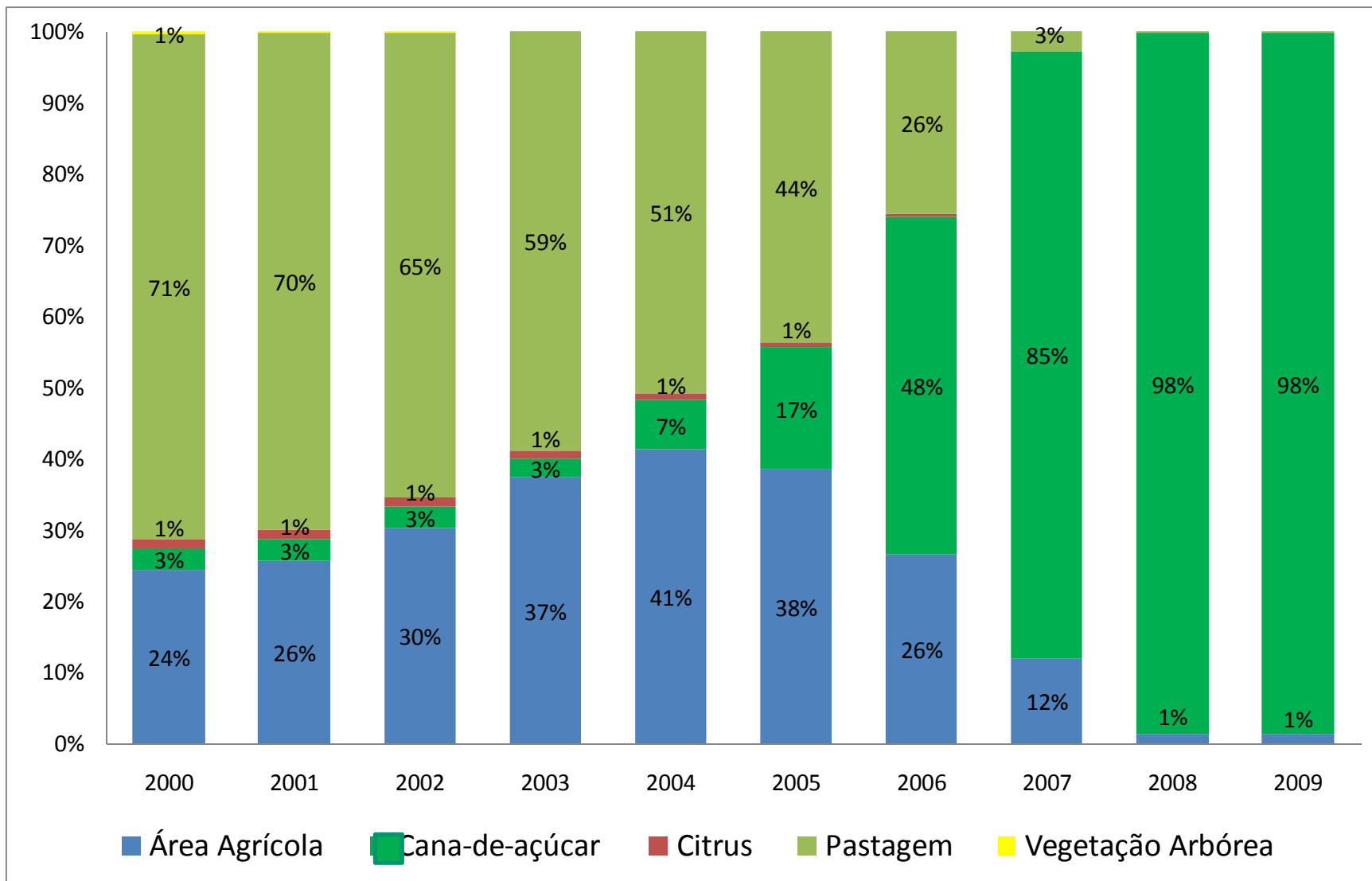
**Erro da Estimativa**  
**-0,7% (~57 mil ha)**

# Plataforma web para avaliação da dinâmica de LUC da expansão da cana



# Dinâmica da Mudança de Uso da Terra da Cana de 2000 a 2009

## Expansão da Cana de 2006 a 2009



Adami, M.; Rudorff, B.; Freitas, R.; Aguiar, D.; Sugawara, L.; Mello, M. Remote Sensing Time Series to Evaluate Direct Land Use Change of Recent Expanded Sugarcane Crop in Brazil. In *Proceedings of the 1st World Sustain. Forum*, 1-30 November 2011; Sciforum Electronic Conferences Series, 2011.



# Outra Aplicações

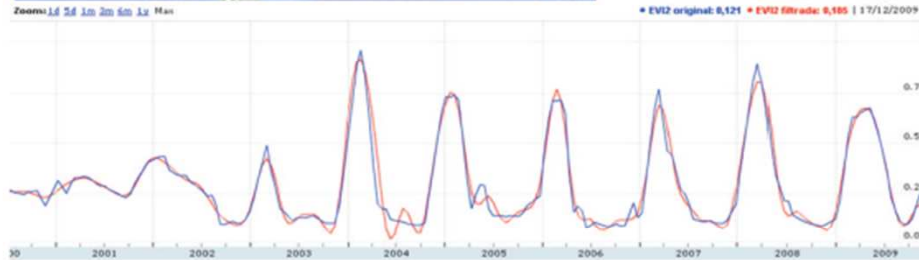
# Virtual Laboratory of Remote Sensing Time-Series

[www.dsr.inpe.br/laf/series](http://www.dsr.inpe.br/laf/series)

VIRTUAL LABORATORY OF REMOTE SENSING TIME-SERIES  
Visualization of MODIS time-series for  
land use and land cover change analyses

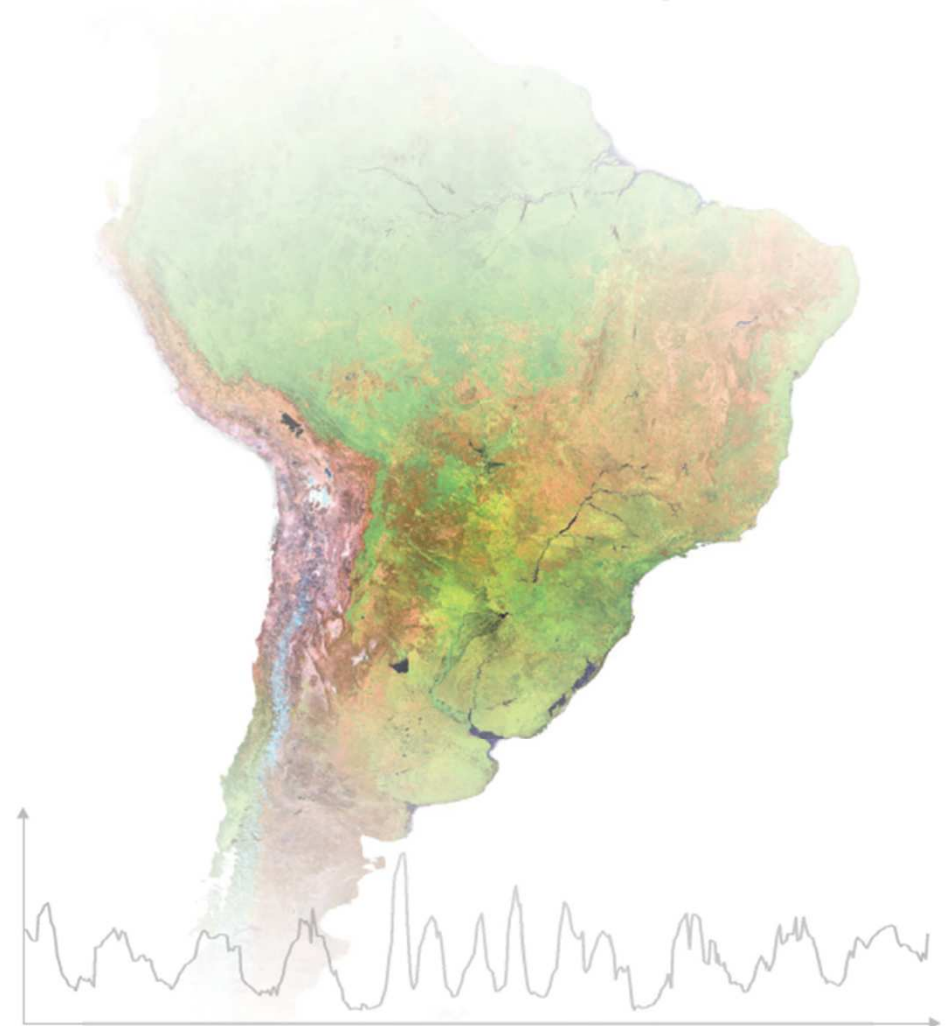


elevação | salvar | favoritos | perfil | sair



Av. dos Astronautas, 1.758, prédio SERE-II, Jd. Granja - ZIP: 12227-010.  
São José dos Campos - SP, Brazil Voice: +55 (12) 3208-6465 e-mail: [laf@dsr.inpe.br](mailto:laf@dsr.inpe.br)

# Visualization of MODIS time-series for land use and land cover change analyses



## Visualization of time-series from the MODIS sensor

Time-series of MODIS<sup>1</sup> images are available for instant visualization, for every pixel, over the South American continent, since the year 2000.

A web tool was developed for instantaneous visualization of MODIS time-series within the concept of a virtual laboratory<sup>2</sup> to support land use and land cover change (LULCC) analyses based on a more than 10 years history of daily MODIS data acquisition.

Each curve of the time-series represents the variation over time of the vegetation index (EVI2) for a user's selected pixel on the virtual globe of Google Maps.

The time-series were constructed based on filtered vegetation index (EVI2) of the MOD13Q1 product (collection 5, 16 days composite at spatial resolution of 250 m) available at NASA (<https://wist.echo.nasa.gov>)<sup>2</sup>.

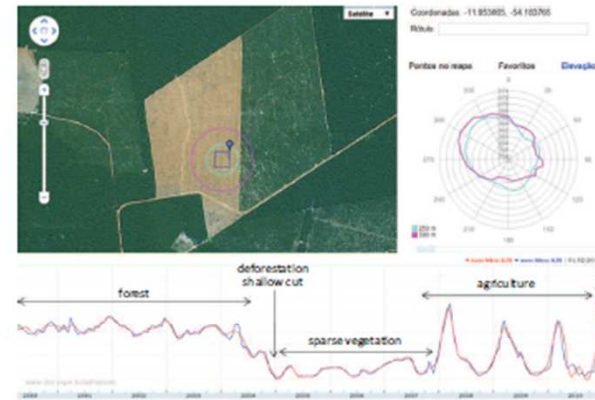
With a minimum of technical knowledge about vegetation dynamics it is possible to retrieve the land use and land cover change history for a given pixel. The figures presented next provide interpreted examples of the land use and land cover change based on the temporal variation of the vegetation index.

The instantaneous visualization of the time-series can be accessed at

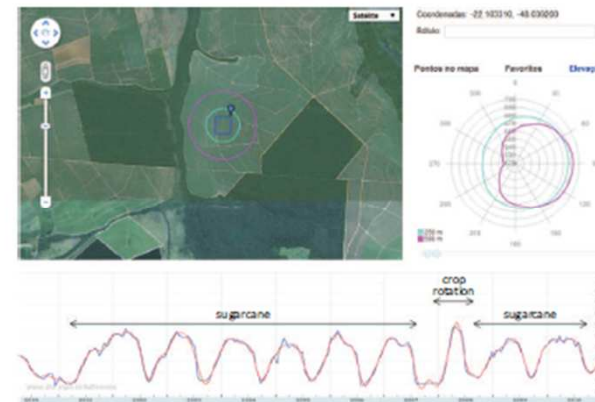
[www.dsr.inpe.br/laf/series](http://www.dsr.inpe.br/laf/series)

<sup>1</sup>Images are from the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor on board of NASA's Terra platform. More information about the sensor can be obtained in: Rudorff, B. F. T., Shimabukuro, Y. E., Ceballos, J. C. O sensor MODIS e suas aplicações ambientais no Brasil (The MODIS sensor and its environmental applications in Brazil). São José dos Campos, SP. Parêntese, 2007, v.1. 425p.

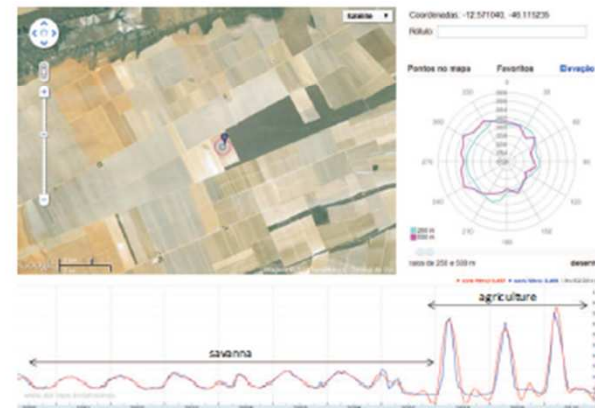
<sup>2</sup>A detailed description about the Virtual Laboratory of Remote Sensing Time-Series and the data filtering procedure can be found in: Freitas, R.M., Arai, E., Adami, M., Ferreira, A. S., Sato, F. Y., Shimabukuro, Y.E., Rosa, R. R., Anderson, L. O., Rudorff, B. F. T. Virtual laboratory of remote sensing time series: visualization of MODIS EVI2 data set over South America, Journal of Computational Interdisciplinary Sciences (JCIS), PACIS, v. 2-1, 2011 (<http://epacis.org/jcis.php>).



The time-series graph shown in this figure refers to the pixel (blue balloon) in Google Maps. Analyzing this time-series it can be noticed the land presented a forest cover until 2004 when it began to be deforested. After deforestation the land remained with sparse vegetation as indicated by the low EVI2 values. By the end of 2007 a summer crop was planted reaching its maximum development in the beginning of 2008 followed by an abrupt decrease of EVI2 values in response to senescence and crop harvest. The same dynamic can be observed for the following crop year.



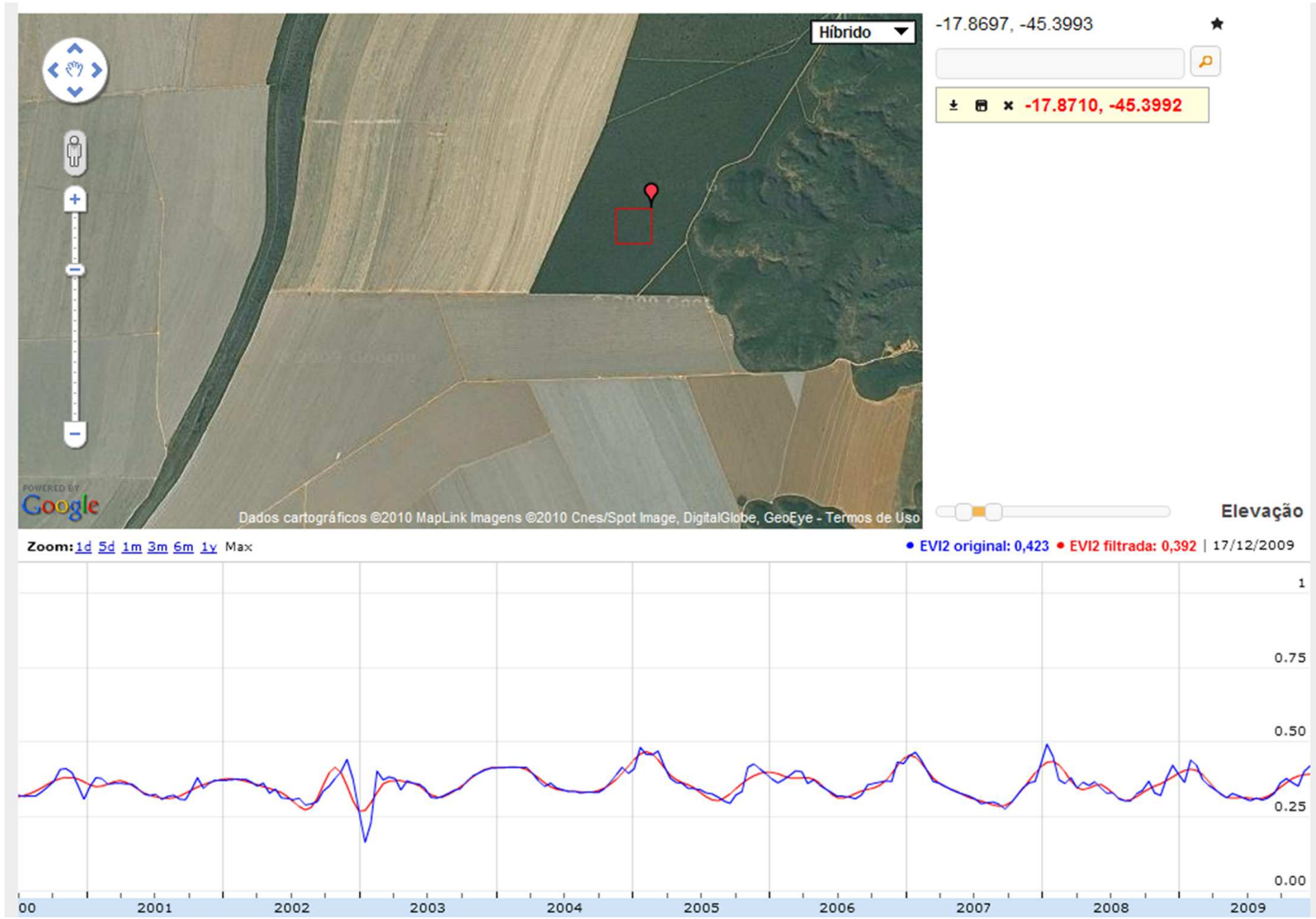
With some knowledge about the sugarcane crop growth cycle one can observe that the pixel (blue balloon in figure next) is from a sugarcane field planted in the beginning of 2001 that grew for a period of about 18 months prior to harvest in mid 2002. During the following five years the field was harvested every year after a growing period of 12 months each year. In 2007, crop rotation was performed with an annual crop (leguminous) followed by a new sugarcane crop. More information on this field can be obtained using the coordinates of the pixel in the Canasat website at: <http://www.dsr.inpe.br/laf/canasat/>



The time-series graph for the pixel (blue balloon) in this figure is from a field within an agricultural region located at the frontier of the Savanna in western Bahia state, Brazil. The region was originally covered by savanna and was gradually converted to intense agricultural land use. This region is characterized by large soybean, corn, cotton and coffee plantations. Considering the shape of the time-series graph one can assume that after 2007 the field was cultivated with a summer crop, possibly soybean or corn. This kind of information is relevant for certification purposes of agricultural crops.

# Município de Buritizeiro, Minas Gerais, Brasil

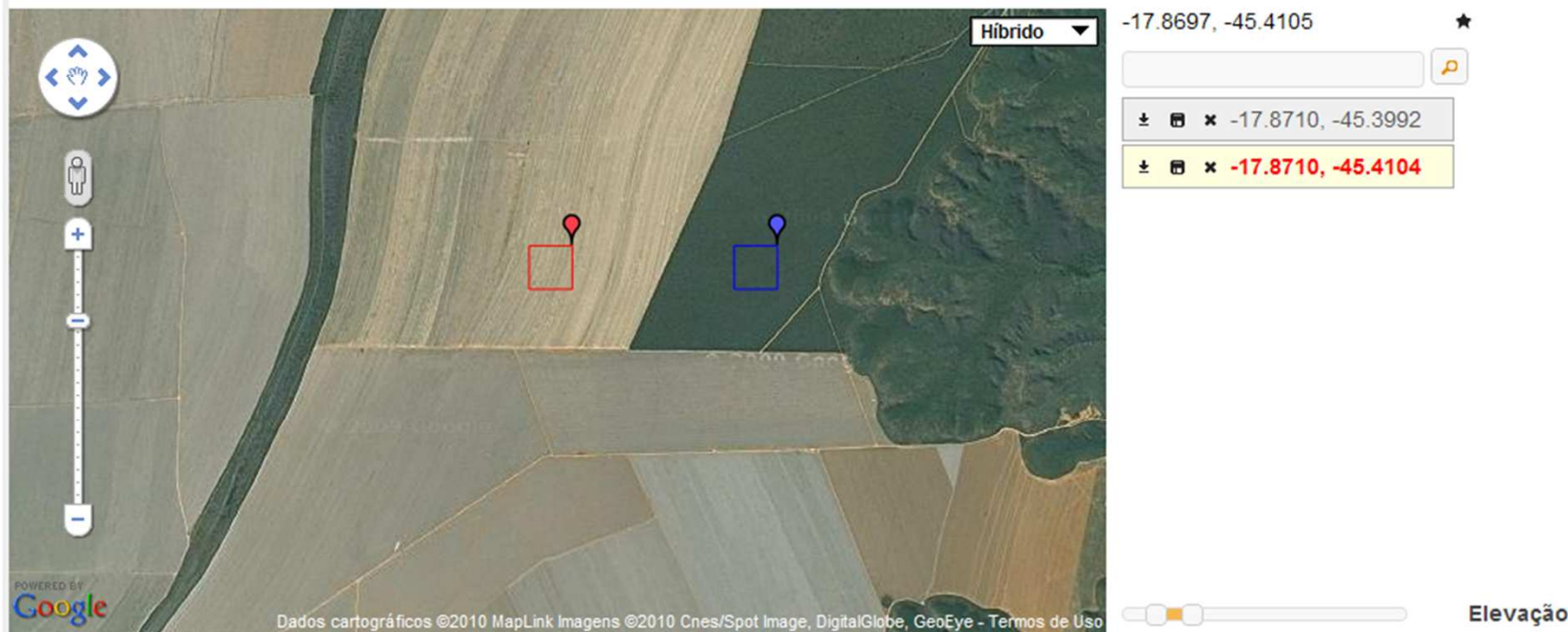
[www.dsr.inpe.br/laf/series/](http://www.dsr.inpe.br/laf/series/)





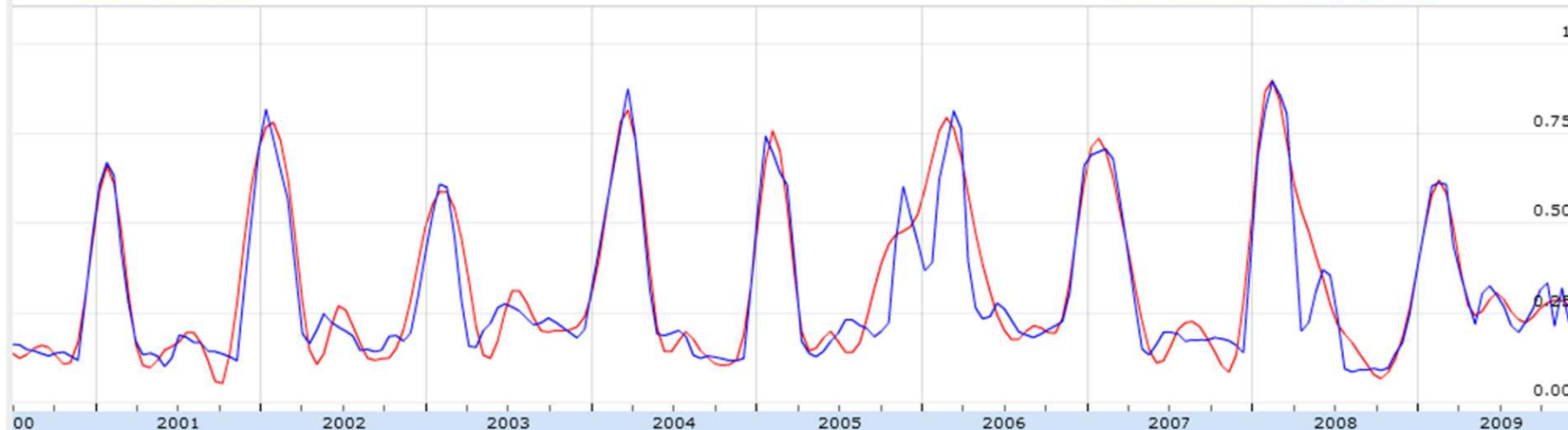
## Gráficos de séries temporais MODIS

Sair



Zoom: [1d](#) [5d](#) [1m](#) [3m](#) [6m](#) [1y](#) Max

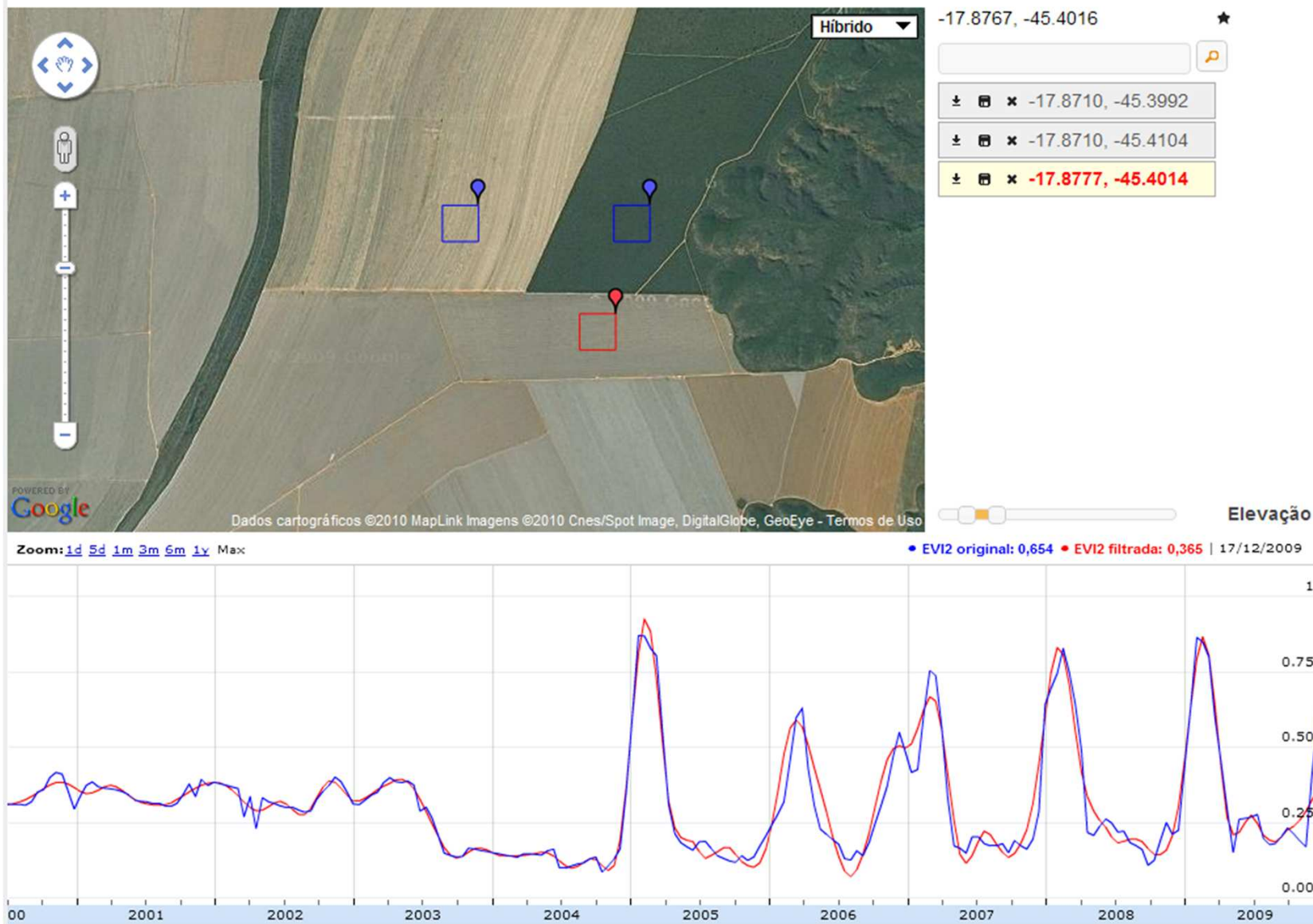
• EVI2 original: 0,22 • EVI2 filtrada: 0,263 | 17/12/2009





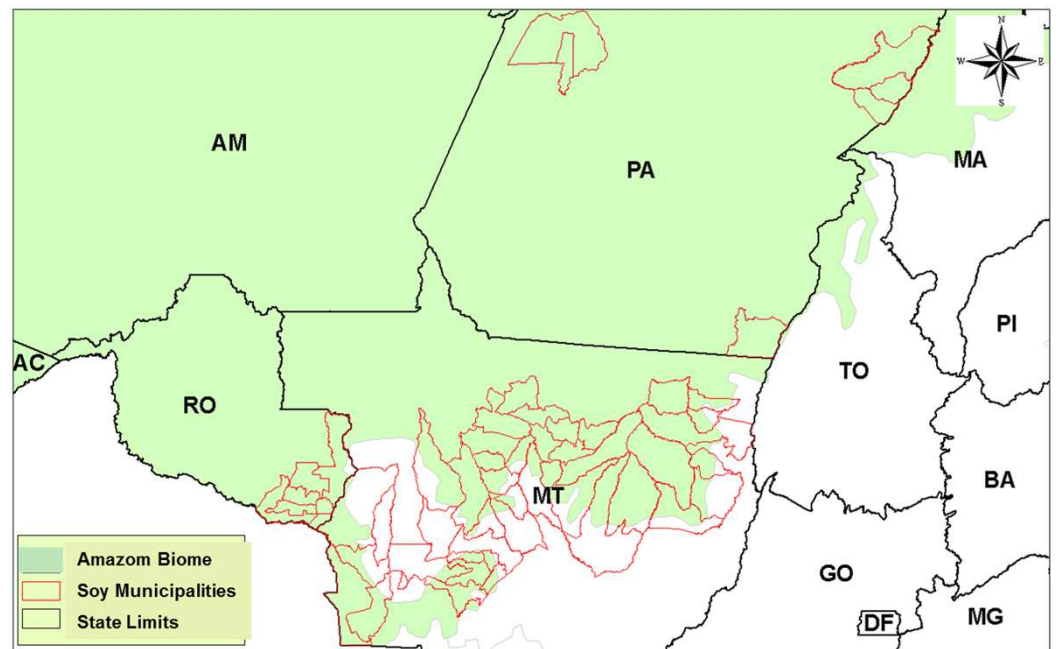
## Gráficos de séries temporais MODIS

Sair

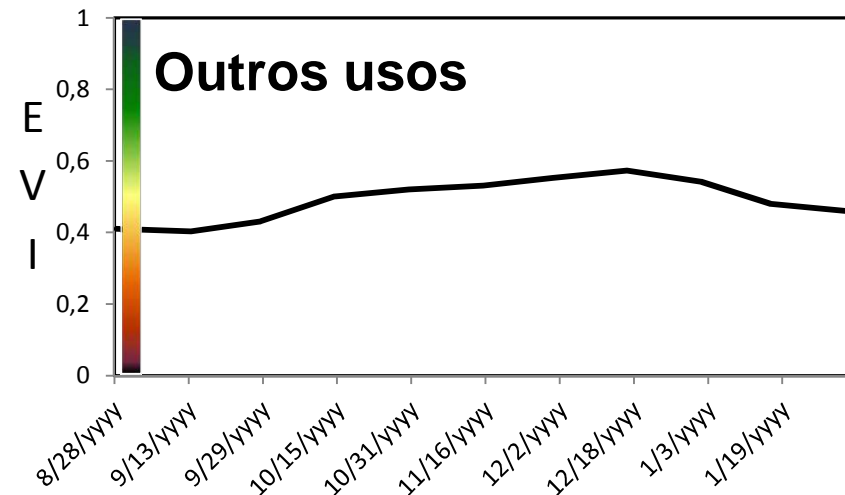
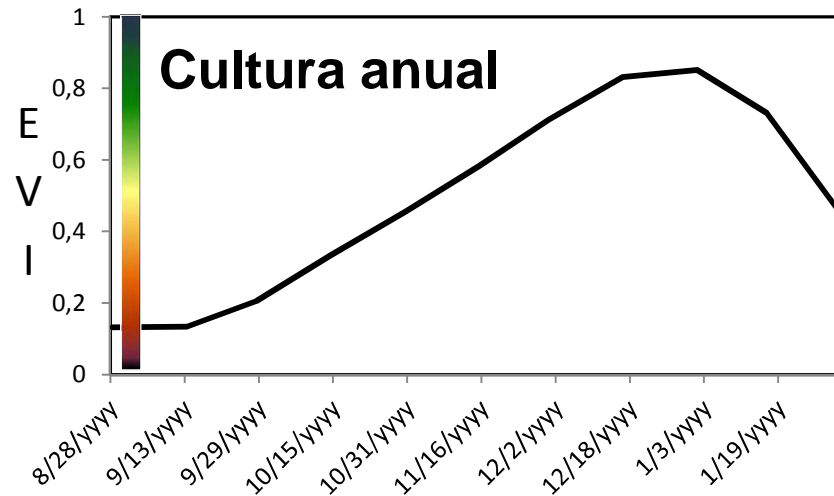
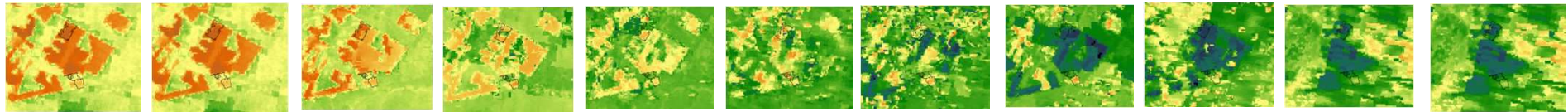


# Moratória da Soja

- **Amazônia Brasileira (4,2 Mkm<sup>2</sup>) e 553 municípios;**
- **7.5% da soja brasileira é produzida no bioma Amazônia(1,9 Mha) em 53 municípios (98%);**
- **Desflorestamento na Amazônia Legal de 2007 a 2010 foi 39.026 km<sup>2</sup>;**
- **Desflorestamento em municípios de soja de 2007 a 2010 foi 4.862 km<sup>2</sup> (12.5%);**
- **A Moratória da Soja teve início em julho de 2006**



# Monitoramento de desflorestamentos do PRODES dentro do contexto da Moratória da Soja



- **Todos polígonos do PRODES (>25 ha) são monitorados com imagens de satélite do sensor MODIS para verificar se existe presença de cultura anual. Isto ocorre em cerca de 10% dos polígonos PRODES e que posteriormente são sobrevoados para identificação dos polígonos com soja.**
- **No 4º ano da Moratória da Soja (2010/11) foram identificados 11.698 ha de soja em desflorestamentos recentes que corresponde a: 0,3% do desflorestamento no bioma Amazônia desde o início da moratória; 2,4% dos desflorestamentos em municípios com mais de 5.000 ha de soja; 3,1% dos desflorestamentos >25 ha e em municípios com mais de 5.000 ha de soja; ou ainda 0,6% da área de soja no bioma Amazônia.**

Rudorff, B.F.T.; Adami, M.; Aguiar, D.A.; Moreira, M.A.; Mello, M.P.; Fabiani, L.; Amaral, D.F.; Pires, B.M. The Soy Moratorium in the Amazon Biome Monitored by Remote Sensing Images. *Remote Sens.* **2011**, 3, 185-202.

Rudorff, B.; Adami, M.; Risso, J.; Aguiar, D.; Pires, B.; Amaral, D.; Fabiani, L.; Cecarelli, I. Remote Sensing Images to Detect Soy Plantations in the Amazon Biome – the Soy Moratorium Initiative. *Sustainability*, 2011.



# Avaliação da data do desflorestamento

## Landsat & a Série-temporal MODIS

