

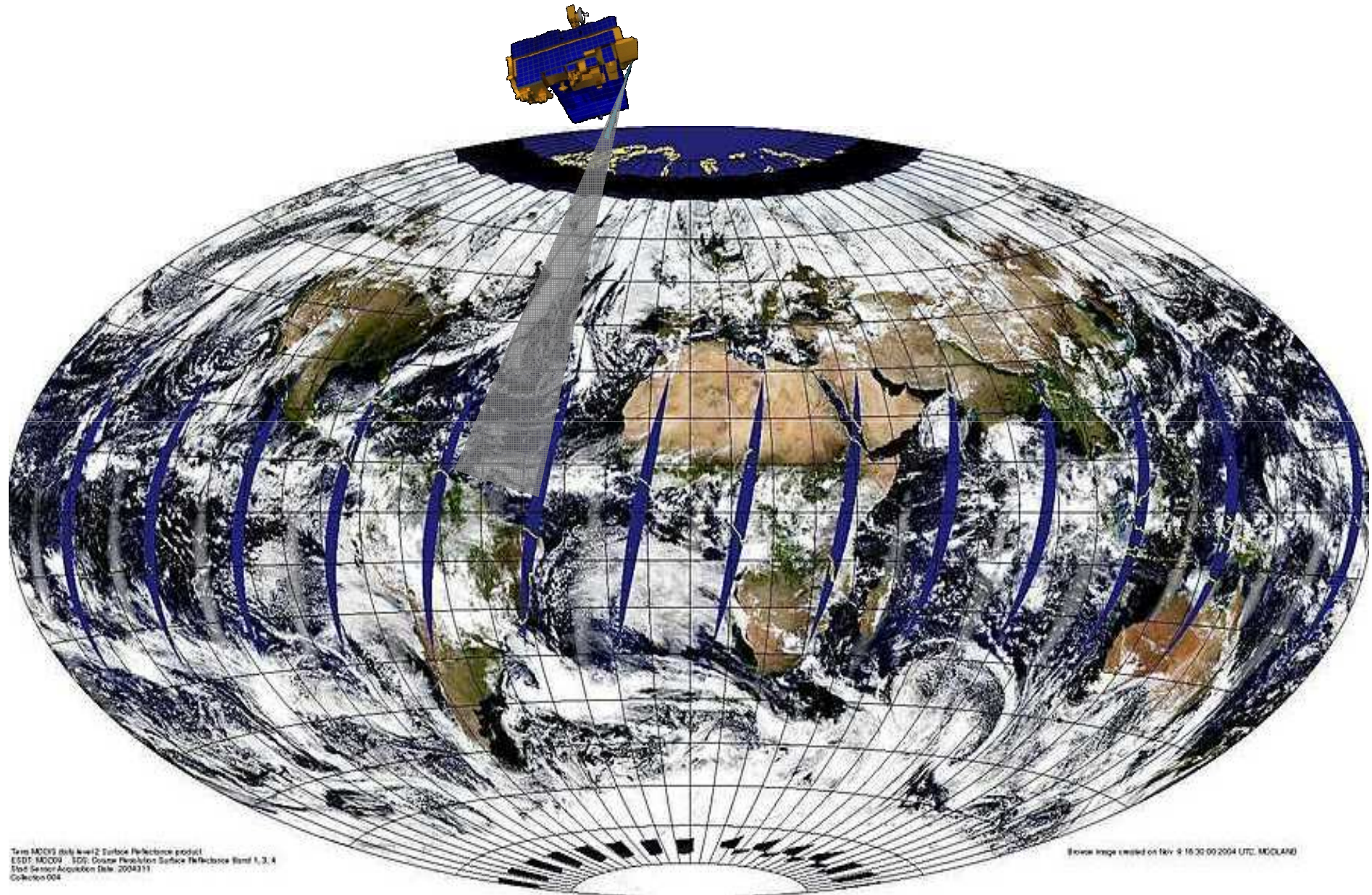
Monitoramento Agrícola via Imagens de Satélite

Daniel Alves Aguiar
Bernardo F. T. Rudorff

São José dos Campos
Junho, 2012

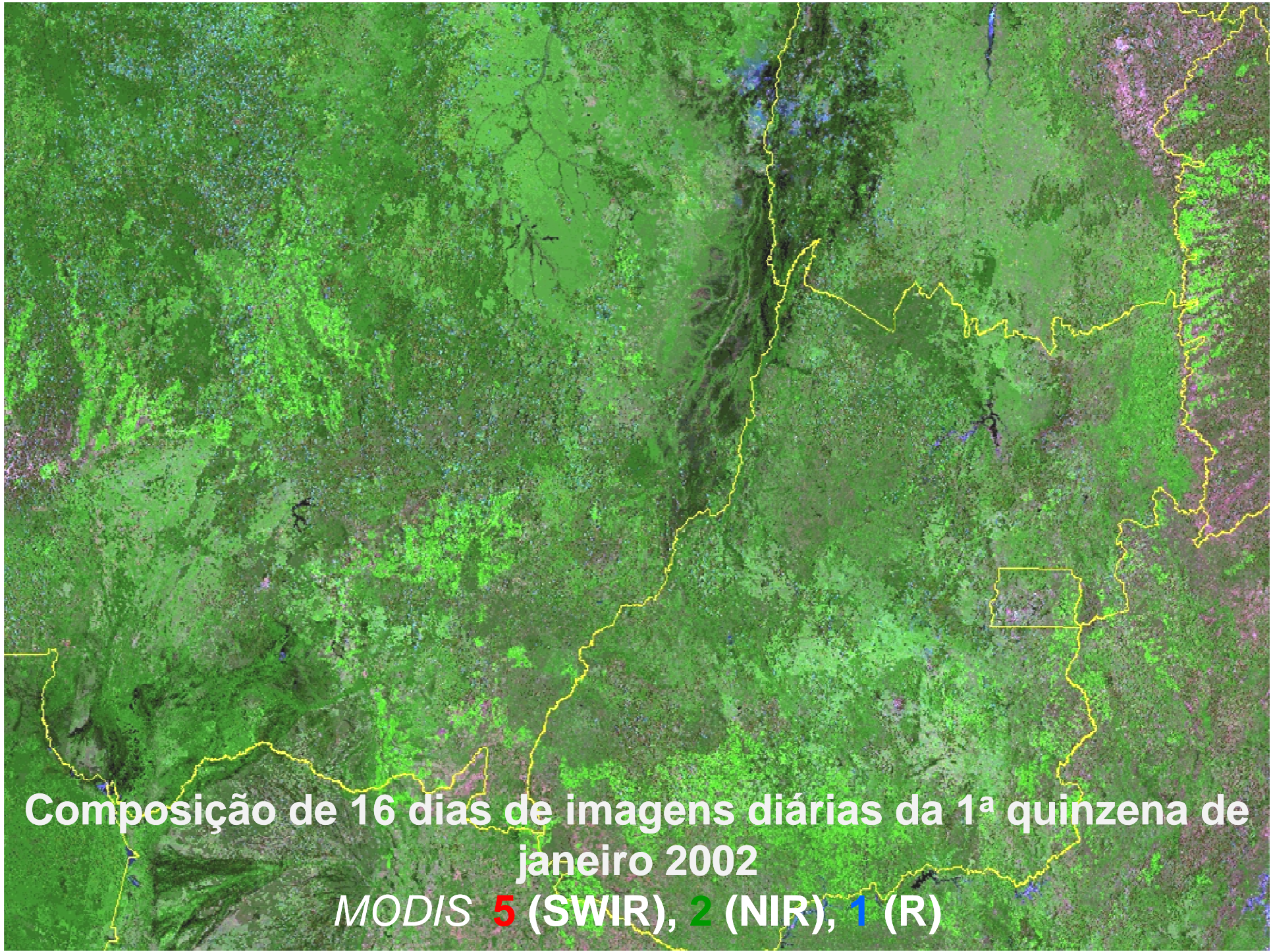
Resolução Temporal

Satélite Terra - Sensor MODIS



Terra MODIS Data Level 2 Surface Reflectance product
EODT: MOD09 - EOD: Ocean Reflection Surface Reflectance Band 1, 3, 4
This Sensor Acquisition Date: 20040311
Collection 004

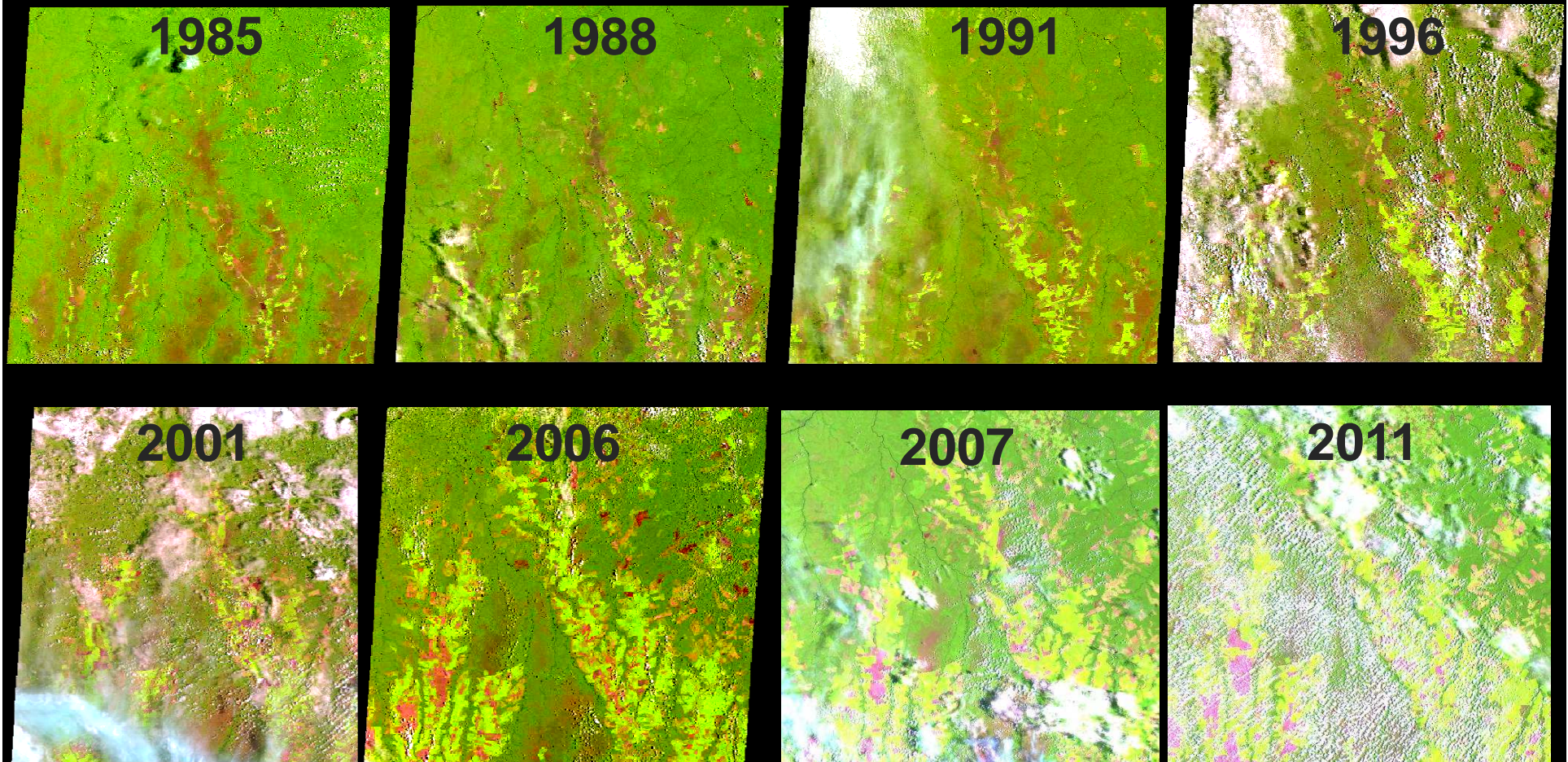
Image Image created on Sat 4 16:20:00 2004 UTC, MODLAND








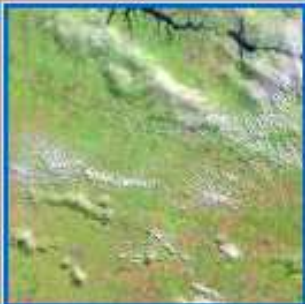
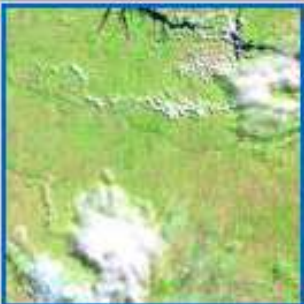


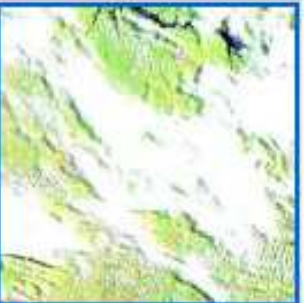








Composição de 16 dias de imagens diárias da 1ª quinzena de janeiro 2002

MODIS 5 (SWIR), 2 (NIR), 1 (R)






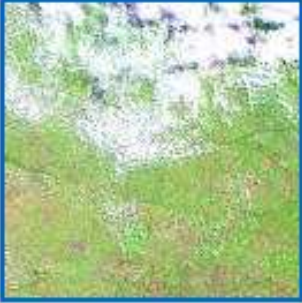





















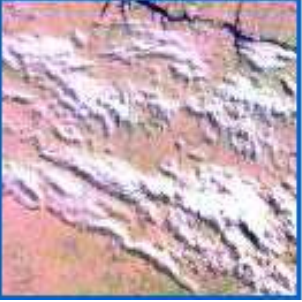
Imagens do Landsat-5 (228/69) “livres de nuvens” de uma região do Mato Grosso para os meses de janeiro e fevereiro (1985 a 2012) - SOJA (1 imagem a cada 3 anos)










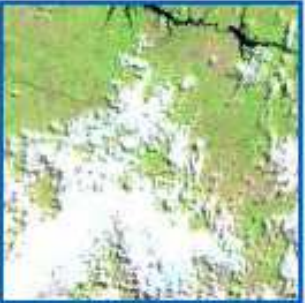















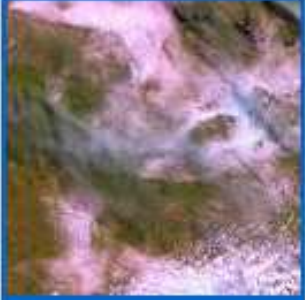


Imagens disponíveis do Landsat-5 (222/75) de 01/09/2007 a 30/04/2008 (CANA)

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	
				
				

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 01/09/2009 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 		
				

Exemplos de aplicações





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**

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

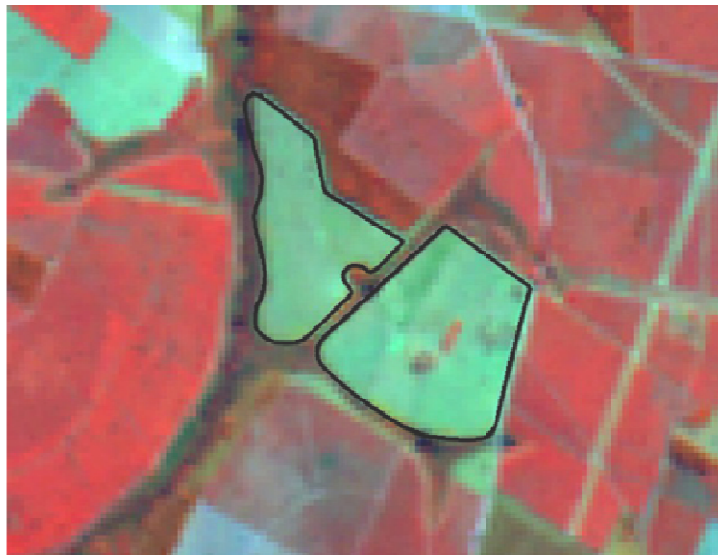
Mapeamento e Previsão da Área Cultivada



- **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**

Rudorff, B.F.T.; Aguiar, D.A.; Silva, W.F.; Sugawara, L.M.; Adami, M.; Moreira, M.A. Studies on the Rapid Expansion of Sugarcane for Ethanol Production in São Paulo State (Brazil) Using Landsat Data. *Remote Sens.* **2010**, 2, 1057-1076.

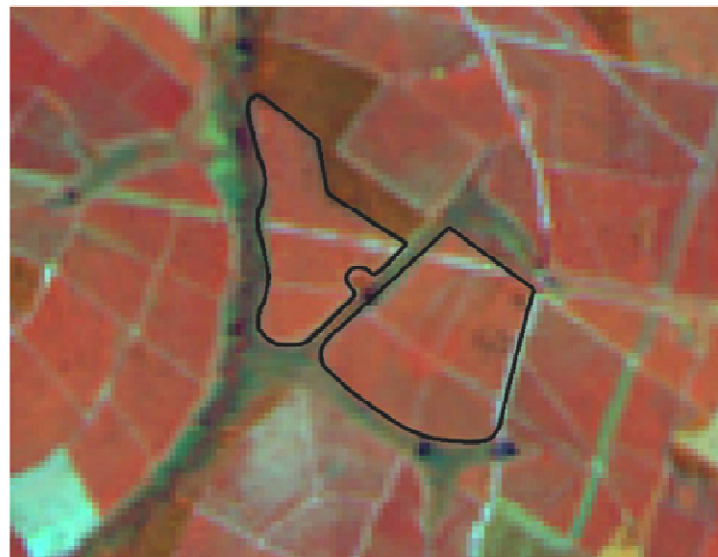
Mapeamento da Expansão – novas áreas de cana



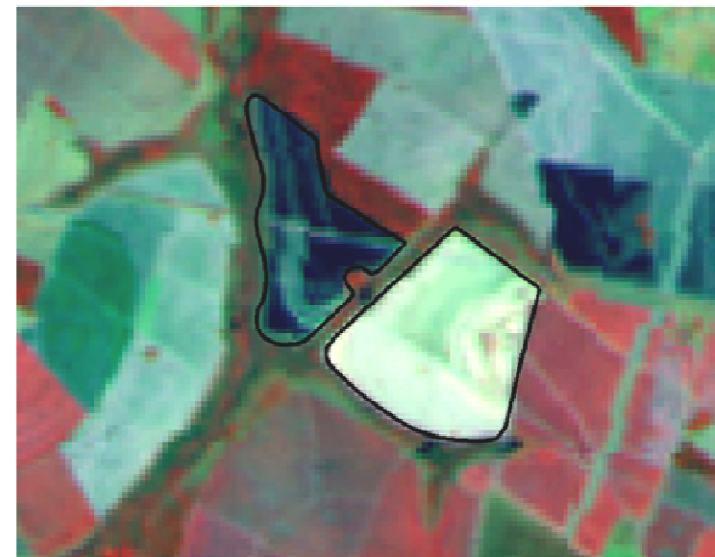
24 abril, 2007



11 junho, 2007

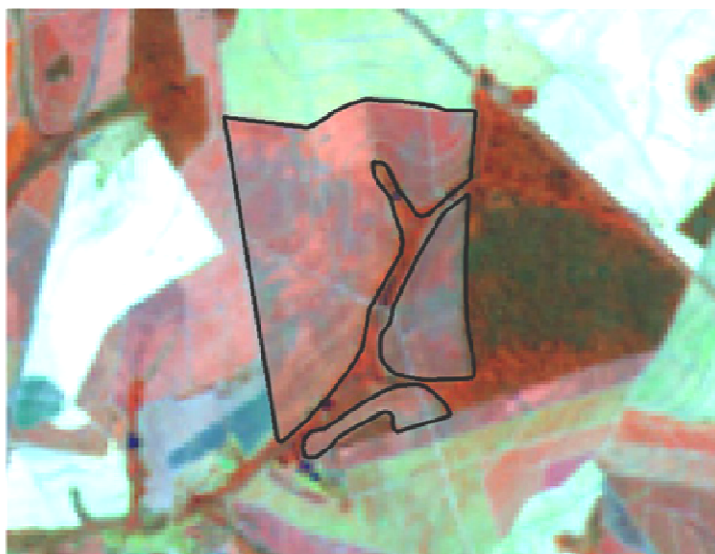


25 março, 2008

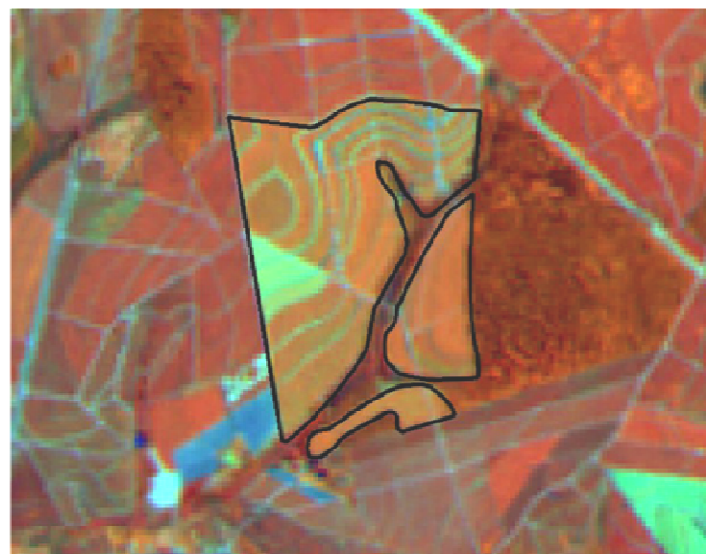


17 setembro, 2008

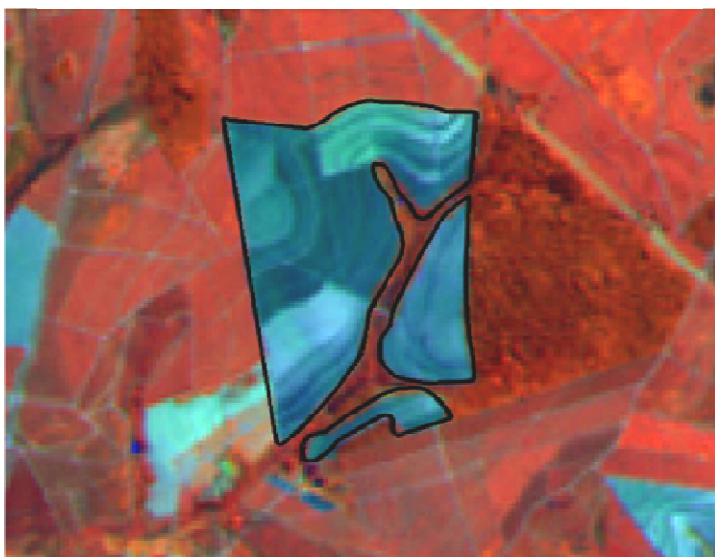
Mapeamento da Renovação – Cana de Ano e Meio



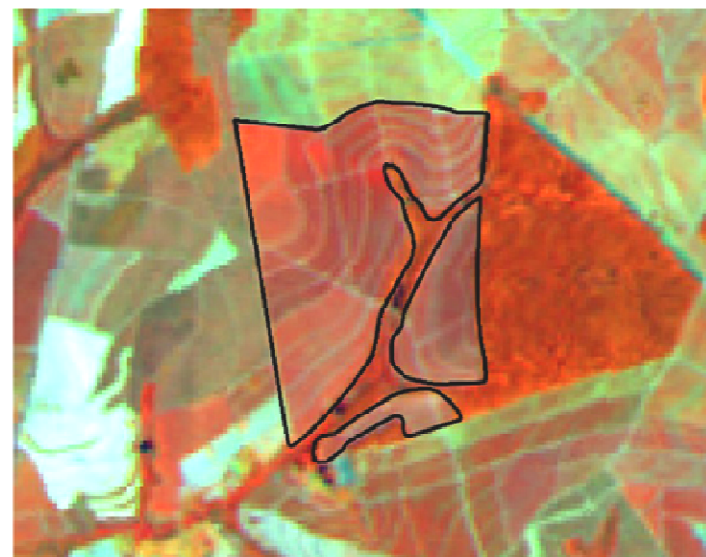
15 setembro, 2007



25 março, 2008



26 abril, 2008



06 dezembro, 2008



realização

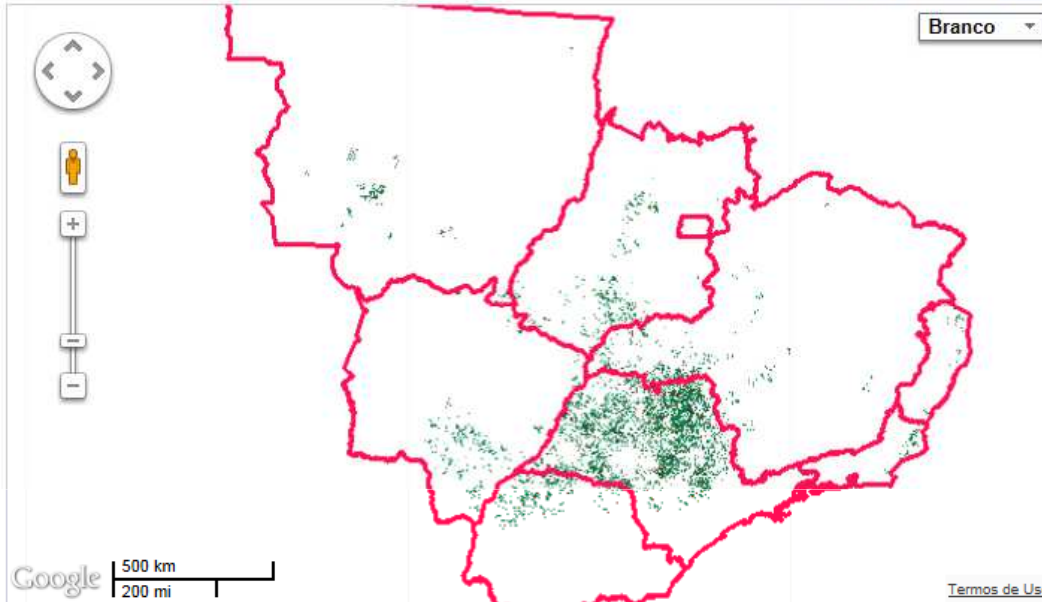


apoio



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

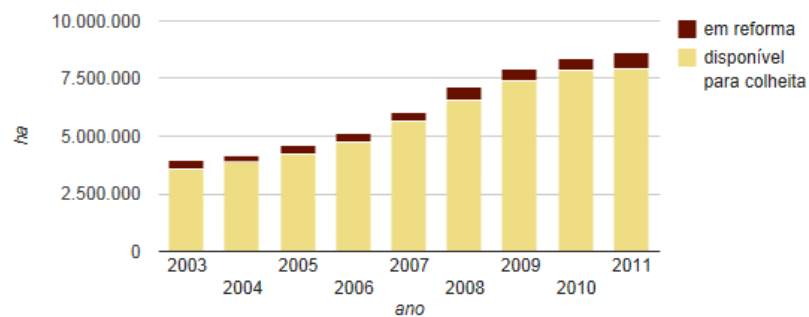
Legenda

- CS
- soca
- reformada
- expansão
- em reforma

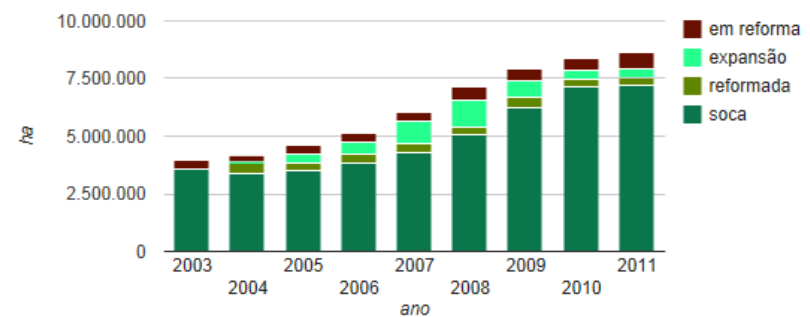
Exibir dados do município de ir ou do estado de Centro-sul ir

Dados da Região Centro-sul

Área disponível para colheita e em reforma



Área cultivada com cana por classe





realização

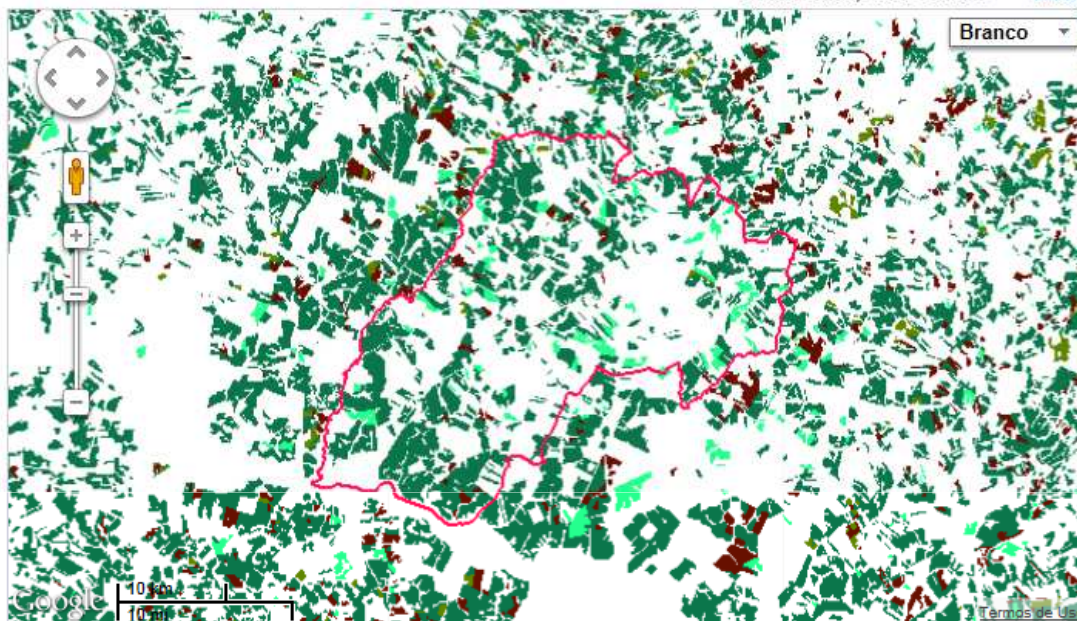


apoio



CEPEA

21 20 04.98 S, 49 37 41.25 O GMS



Camadas do mapa

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

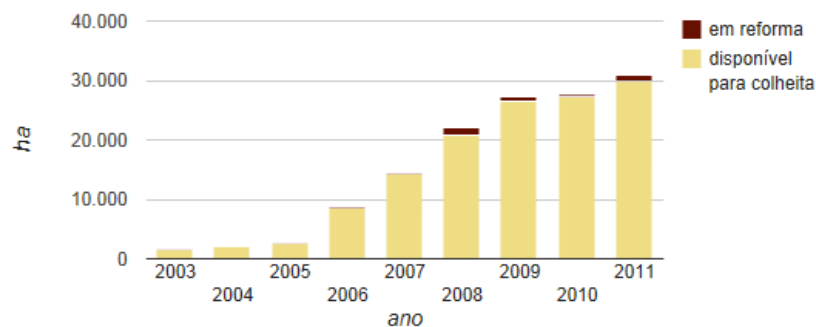
Legenda

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

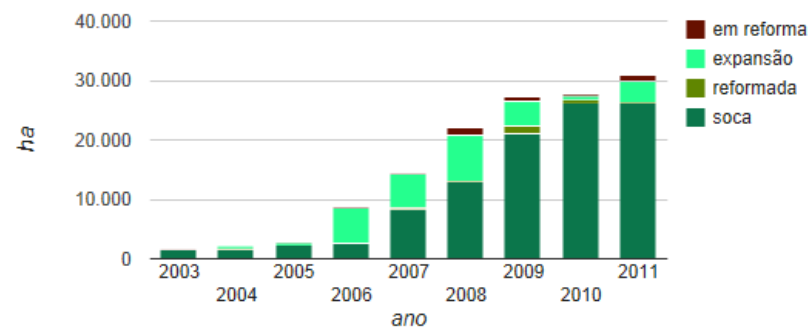
Exibir dados do município de ou do estado de

Dados do município de José Bonifácio - SP

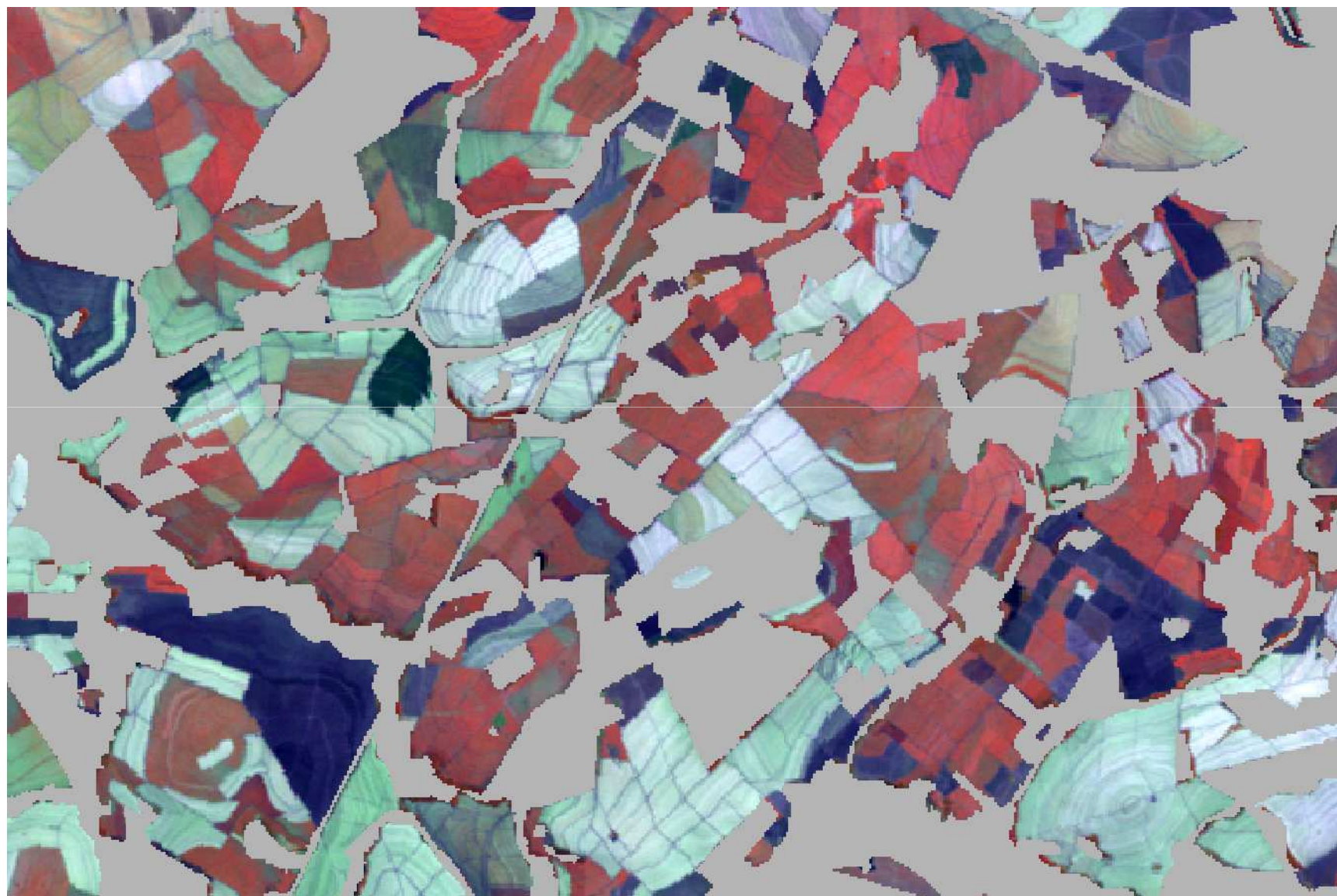
Área disponível para colheita e em reforma



Área cultivada com cana por classe

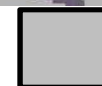


Colheita sem queima e Colheita com queima



Landsat-5

18 Agosto 2011



Outros usos



Monitoramento da Colheita da Cana-de-açúcar
via imagens de satélite

apresentação dados equipe publicações

realização



apoio



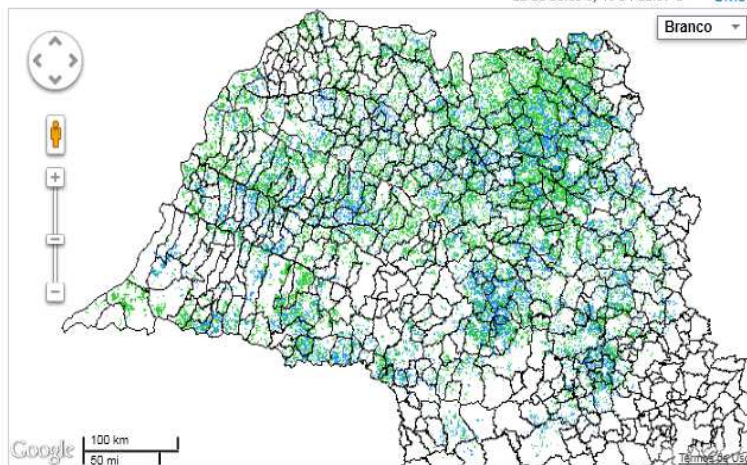
22 11 10.69 S, 46 34 12.07 O GMS

Camadas do mapa

- Estados
- Regiões Administrativas (RA)
- Municípios
- Colheita - safra 2011
- Colheita - safra 2010
- Colheita - safra 2009
- Colheita - safra 2008
- Colheita - safra 2007
- Colheita - safra 2006

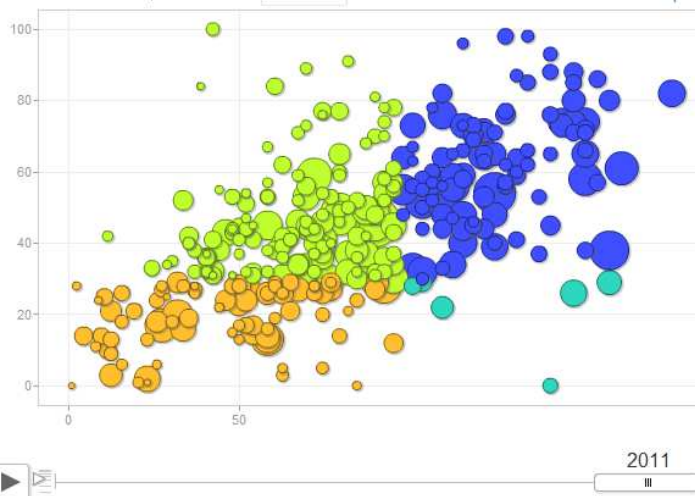
Legenda

- ∨ municípios
- colhida crua
- colhida com pré-queima

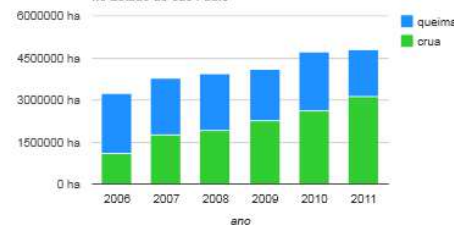


Exibir dados do município de ir Exibir dados da RA Araçatuba ir

Gráfico dos municípios com mais de 1000 ha colhidos



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



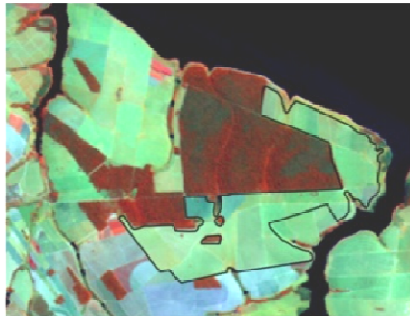
Área colhida crua, com pré-queima e total colhido no Estado de São Paulo

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.

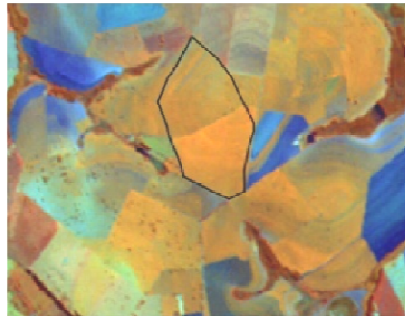
Mudança de Uso da Terra

Pasto



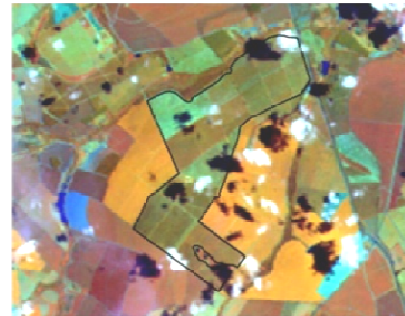
6a) 12/09/06

Soja



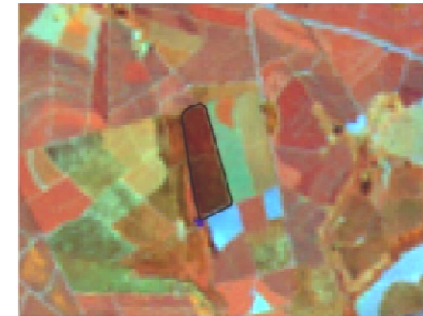
7a) 21/04/06

Citros

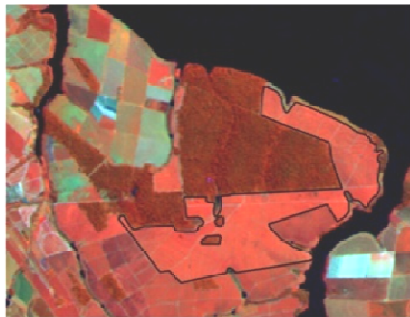


8a) 04/03/06

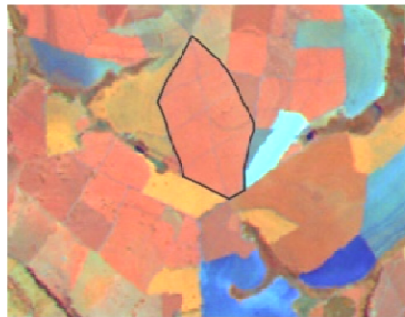
Vegetação Arbórea



9a) 21/04/06



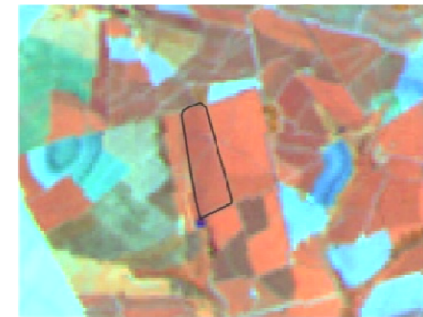
6b) 26/04/08



7b) 26/04/08

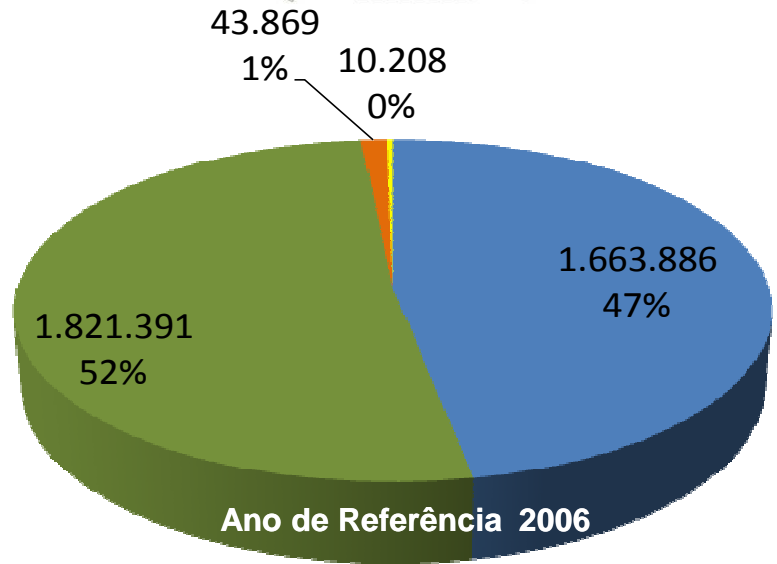
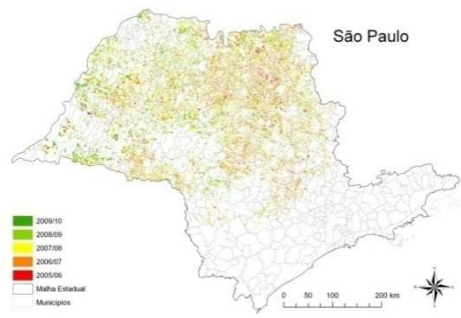
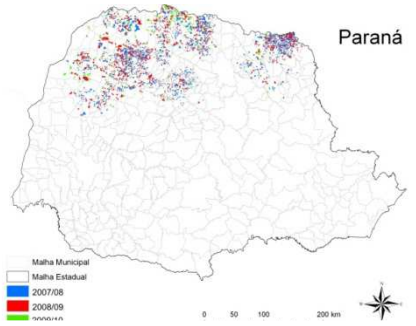
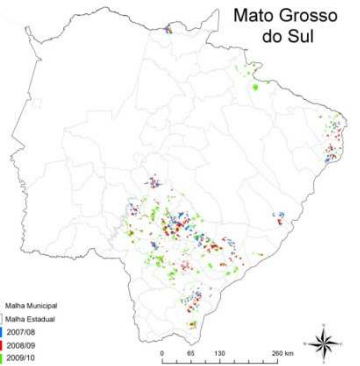
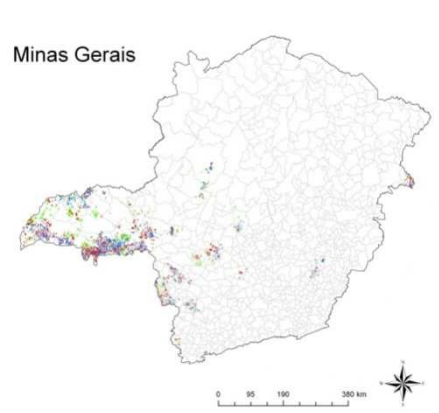
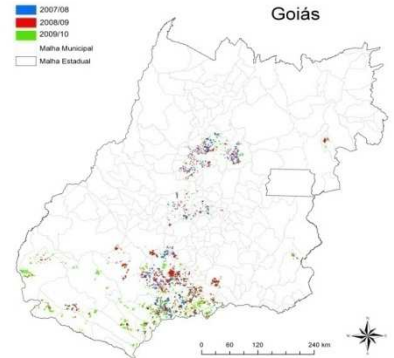
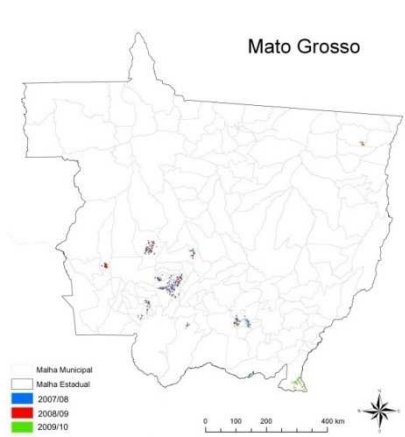


8b) 26/04/08



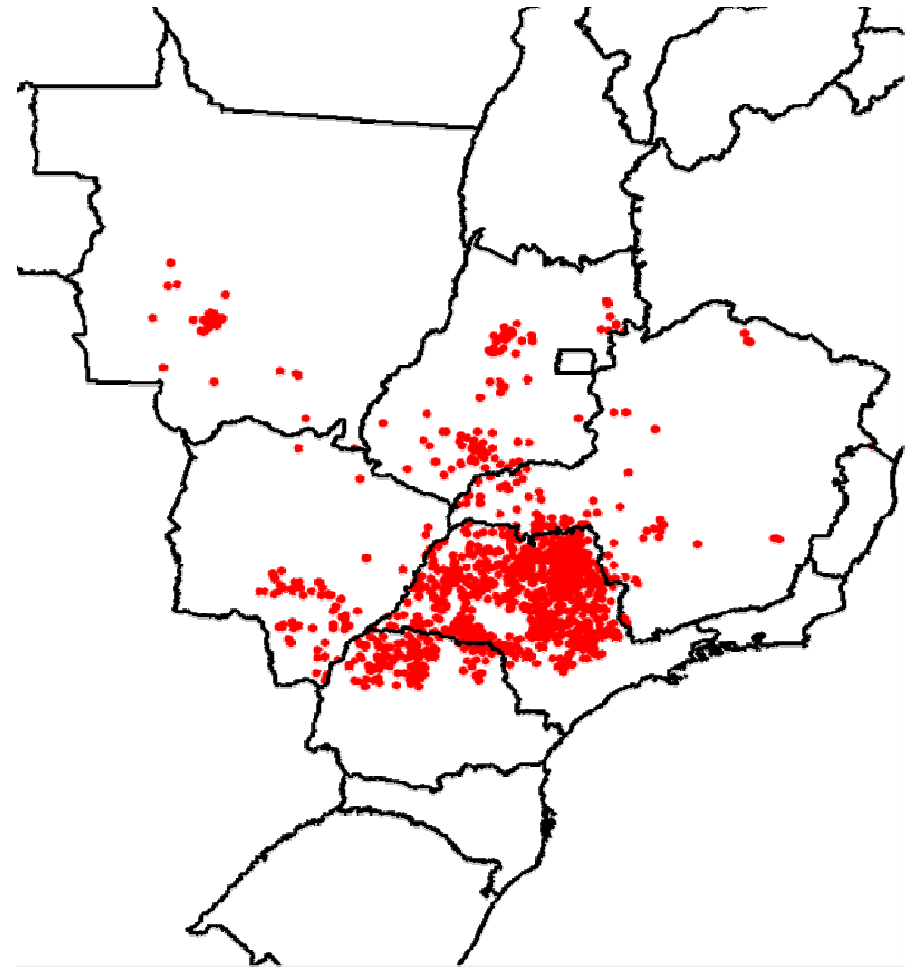
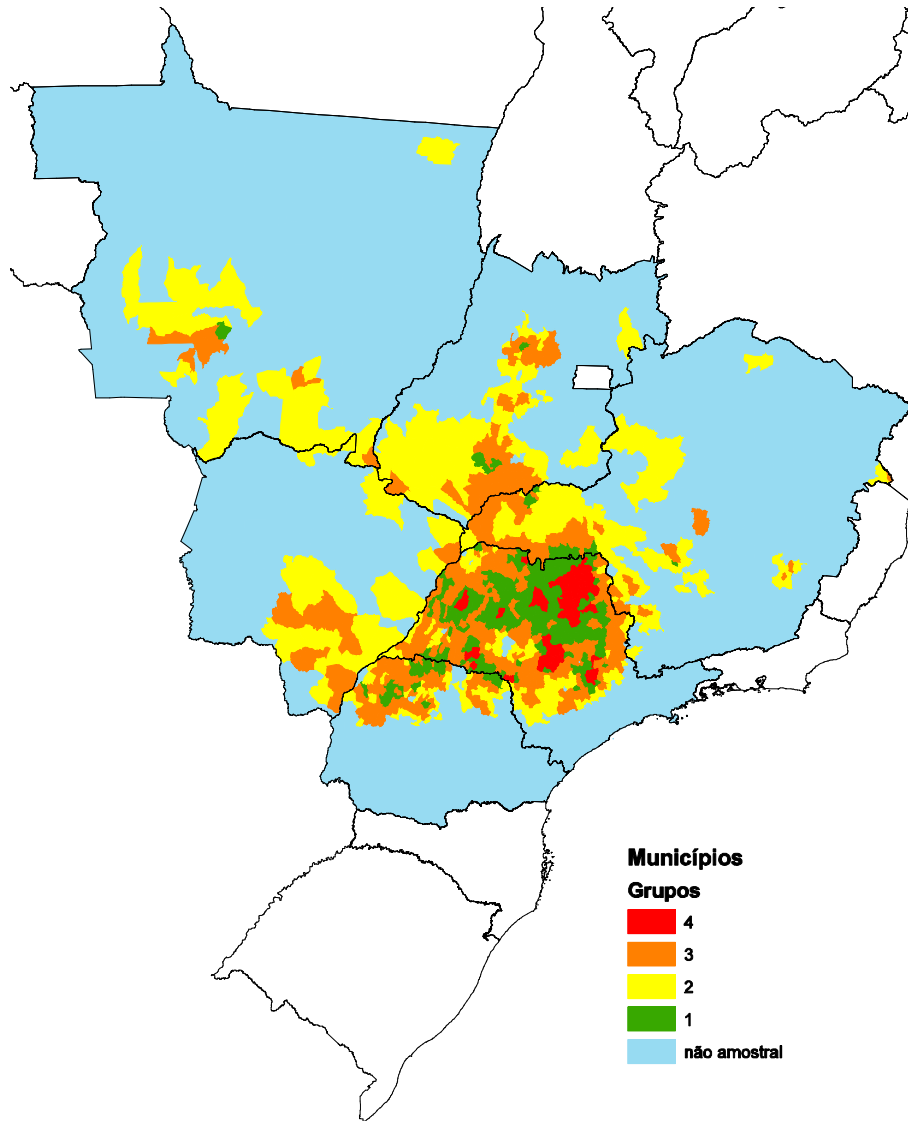
9b) 26/04/08

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



- Agrícola
- 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

LAF 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	45	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

Canas sim não

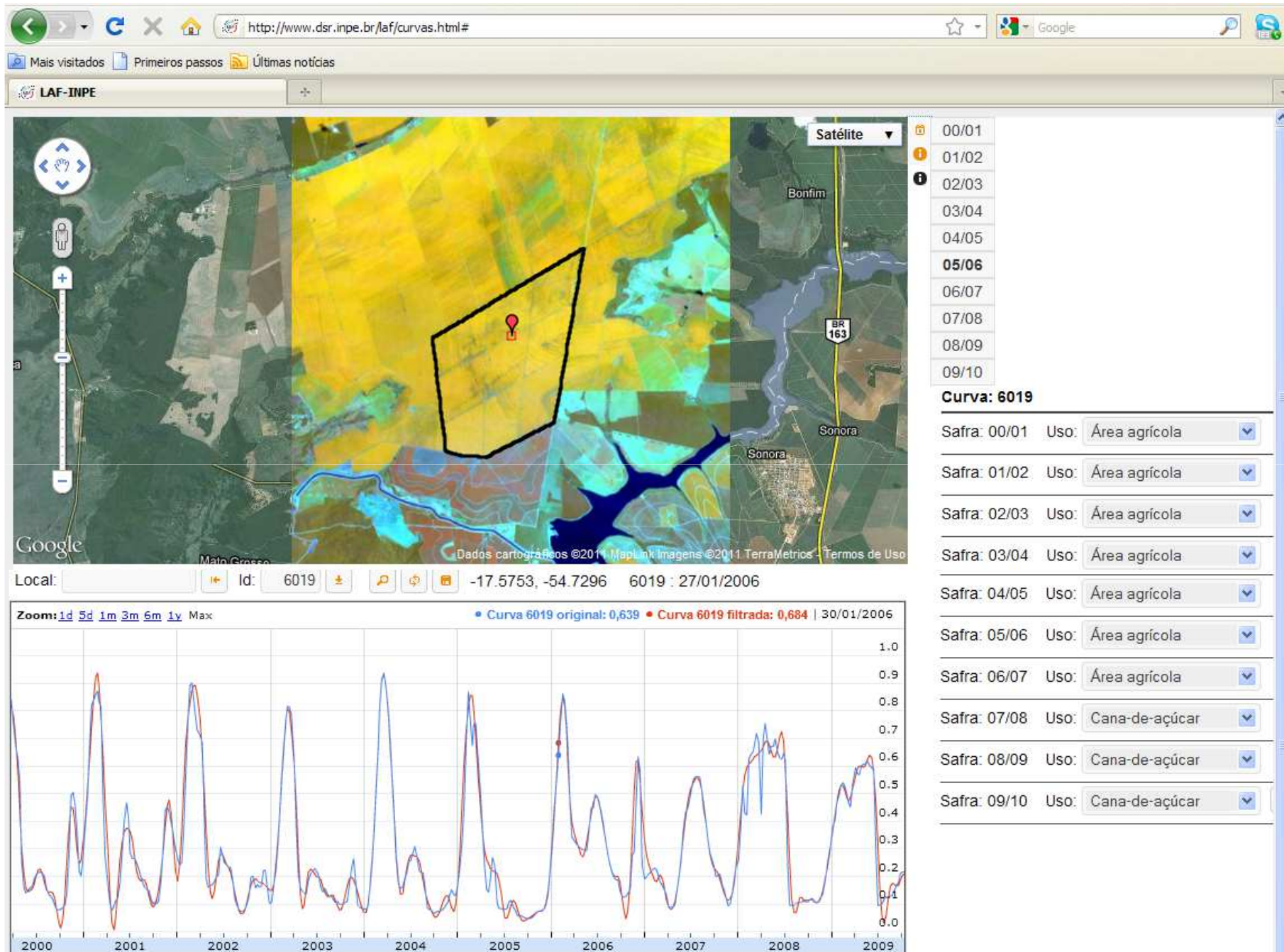
Salvar **Remover**

2001 2002 2003 2004 2005 2006 2007 2008 2009

Acurácia Geral
98%

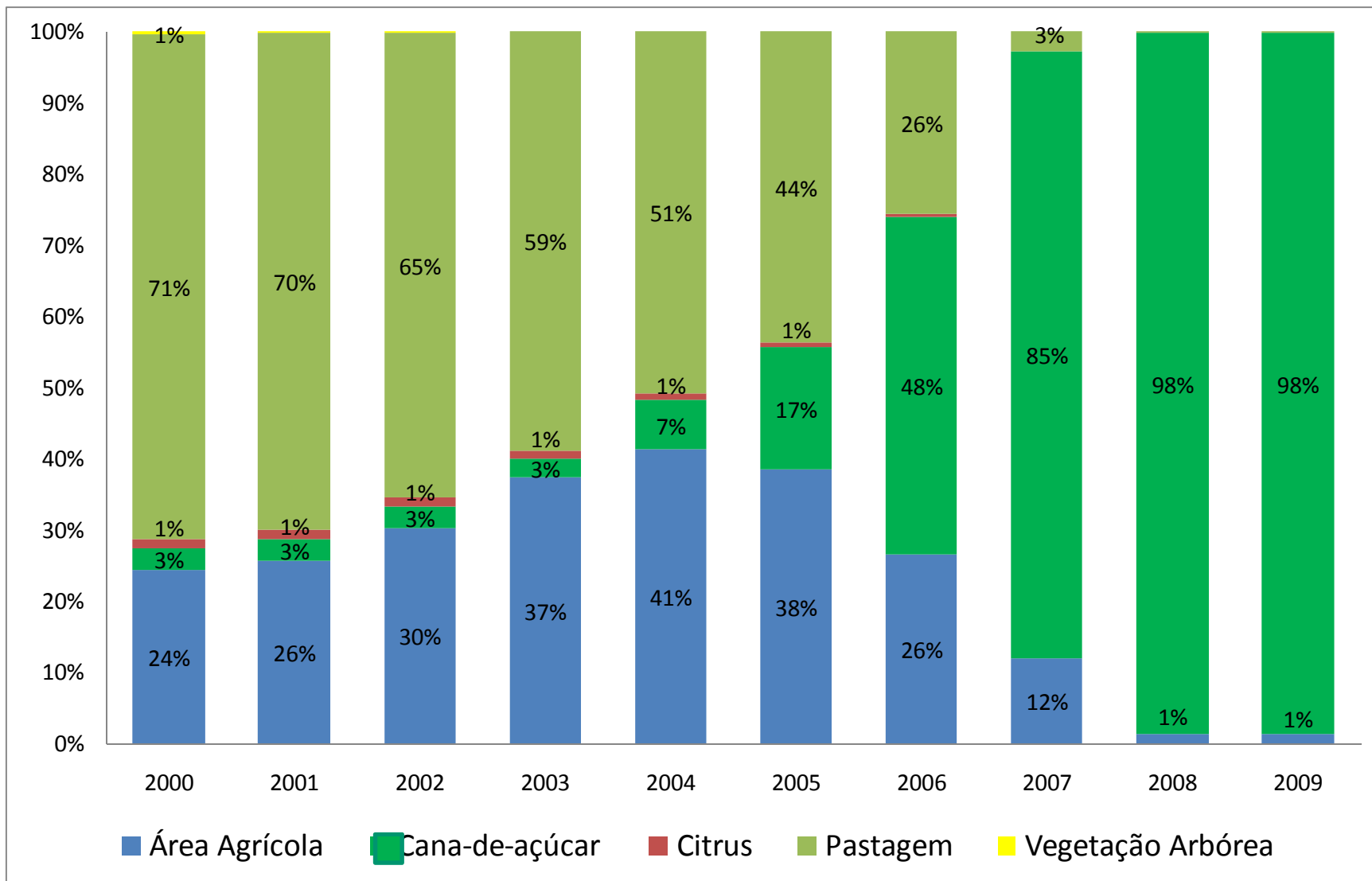
Erro da Estimativa
-0,7% (~-57 mil ha)

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

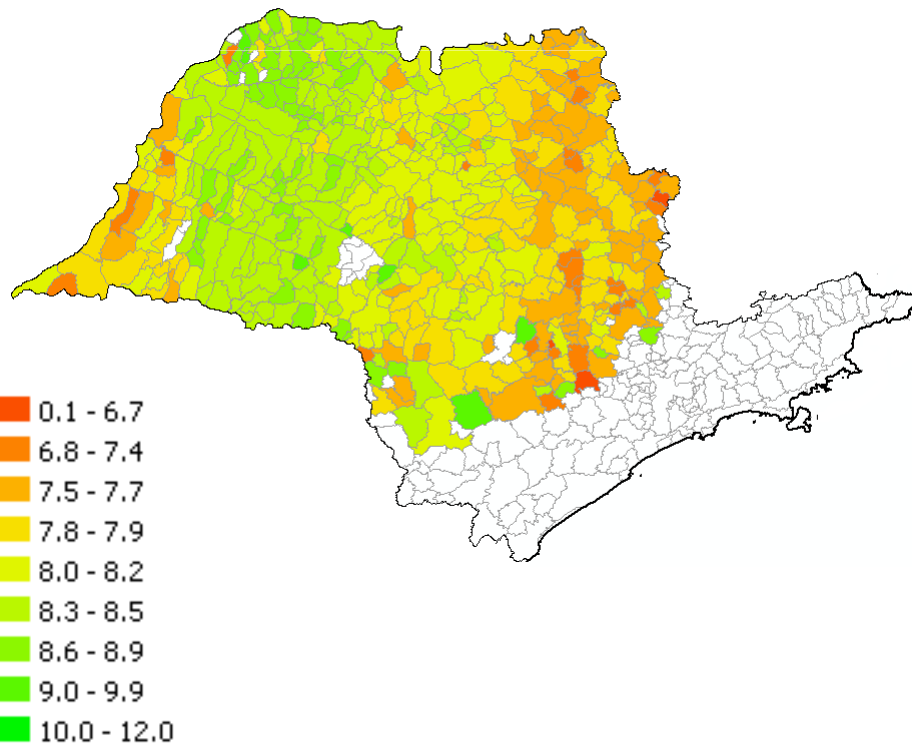
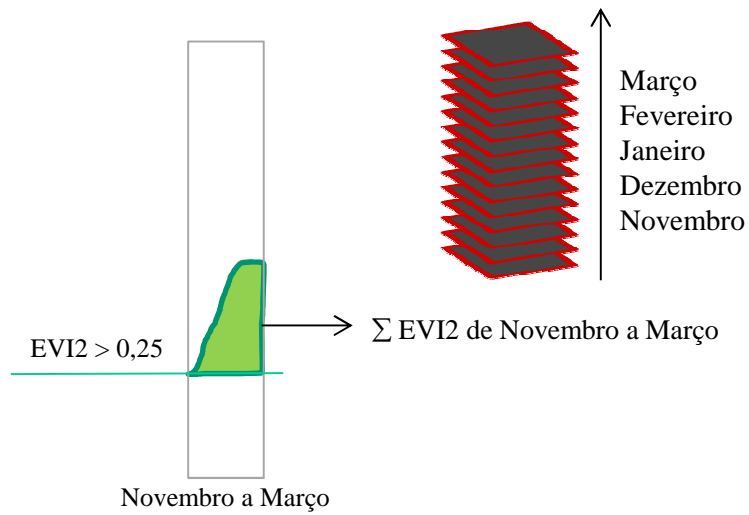


Adami, M.; Rudorff, B.; Freitas, R.; Aguiar, D.; Sugawara, L.; Mello, M. Remote Sensing Time Series to Evaluate Direct Land Use Change of Recent Expanded Sugarcane Crop in Brazil. In *Proceedings of the 1st World Sustain. Forum*, 1-30 November 2011; Sciforum Electronic Conferences Series, 2011.

Desafios/opportunidades para a aplicação de VANTs em agricultura

1) Cana-de-açúcar:

- Estimativa de produtividade; detecção de falhas no talhão decorrentes de problemas no plantio e no manejo. Escala: Usina.
- Resolução de dúvidas sobre modo de colheita.
- Otimização da etapa de validação dos mapas.



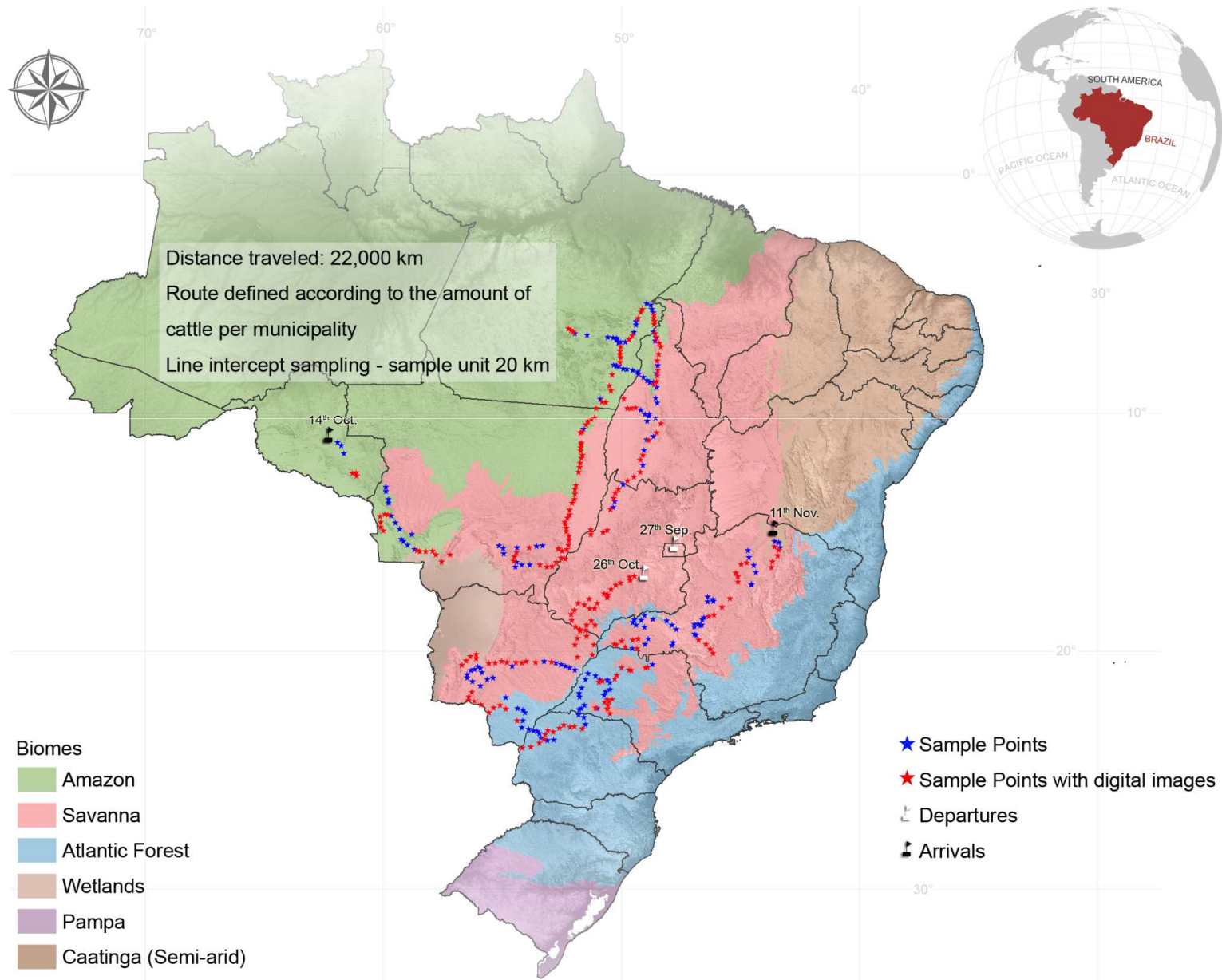
Σ EVI2 de Novembro a Março por pixel puro



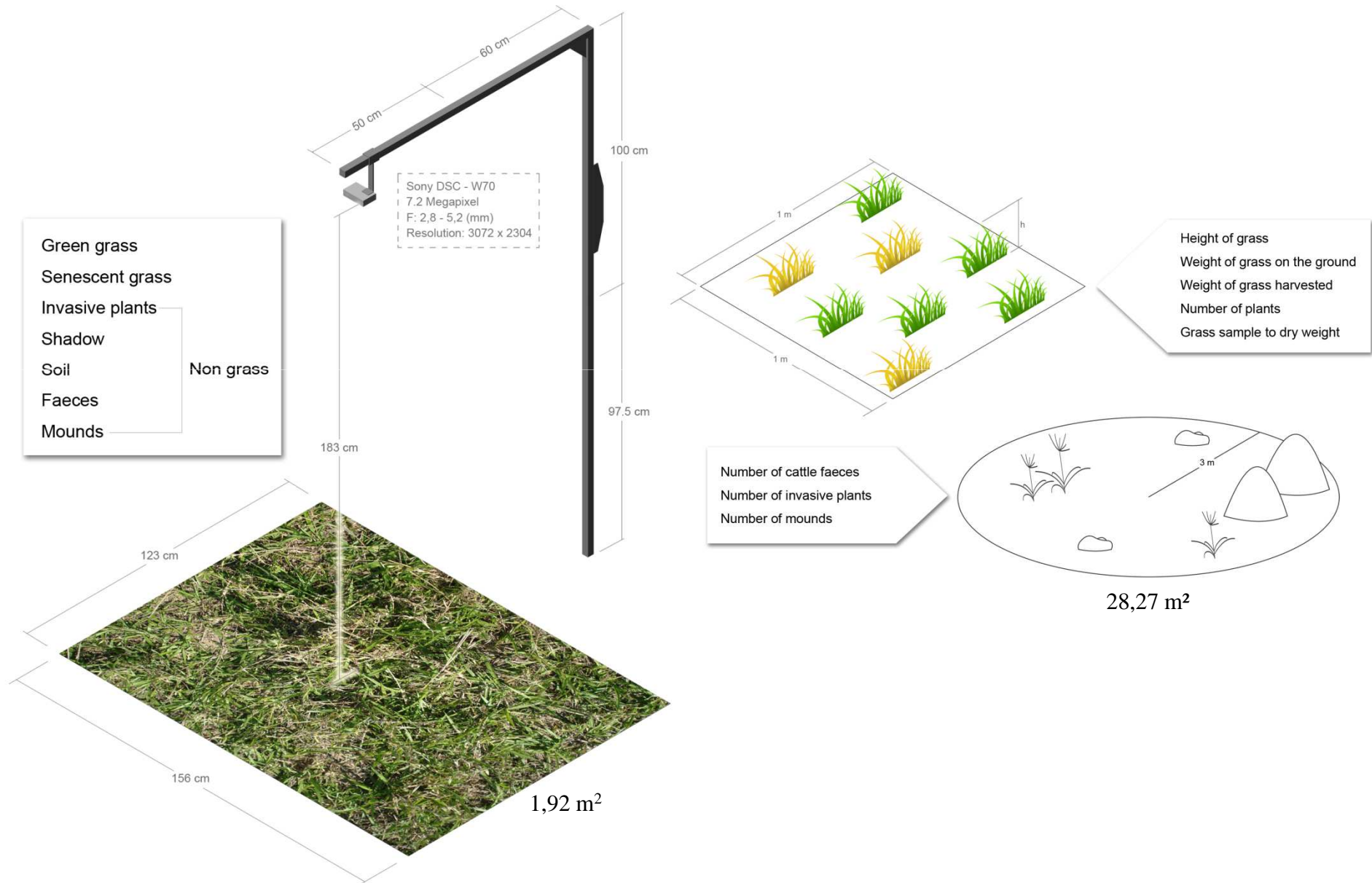
Média por bloco do Σ EVI2 dos pixels totalmente contidos



Avaliação de degradação das pastagens



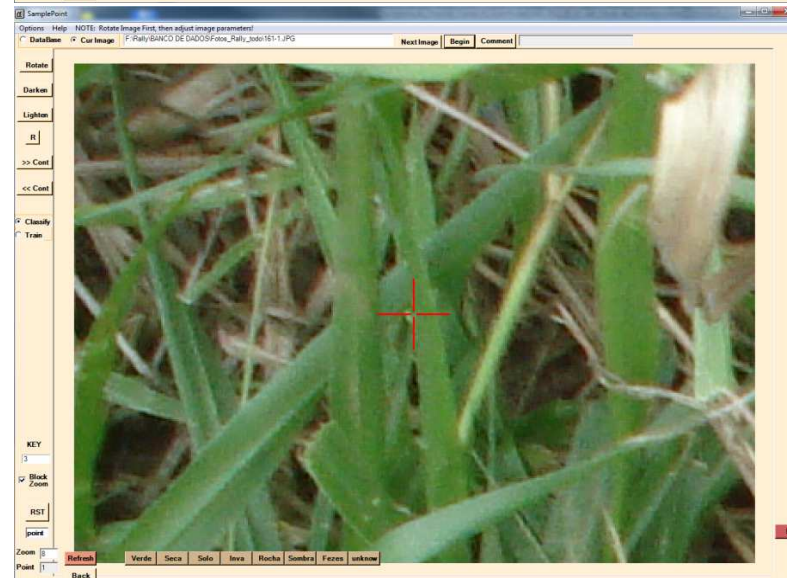
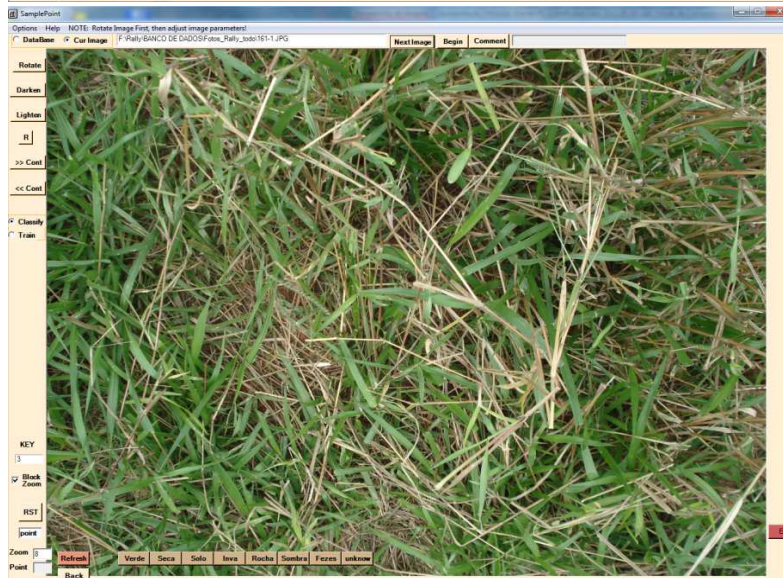
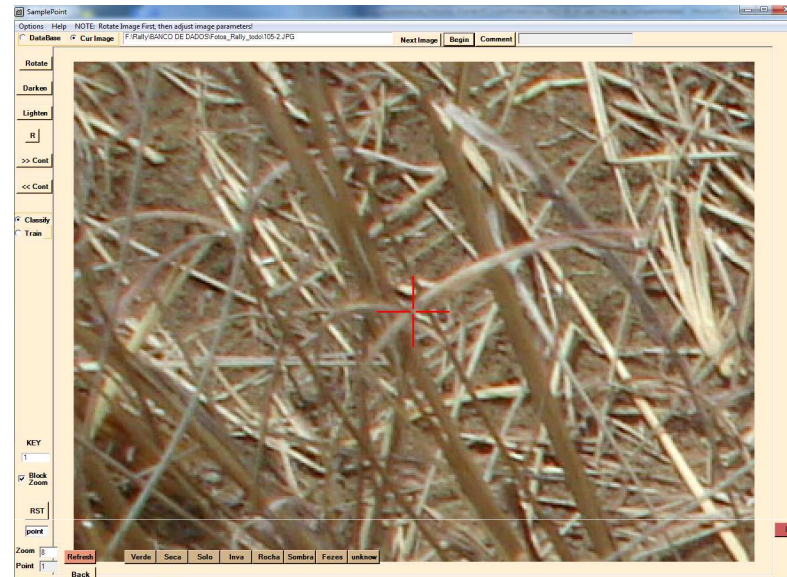
Obtenção dos parâmetros biofísicos



Imagens digitais



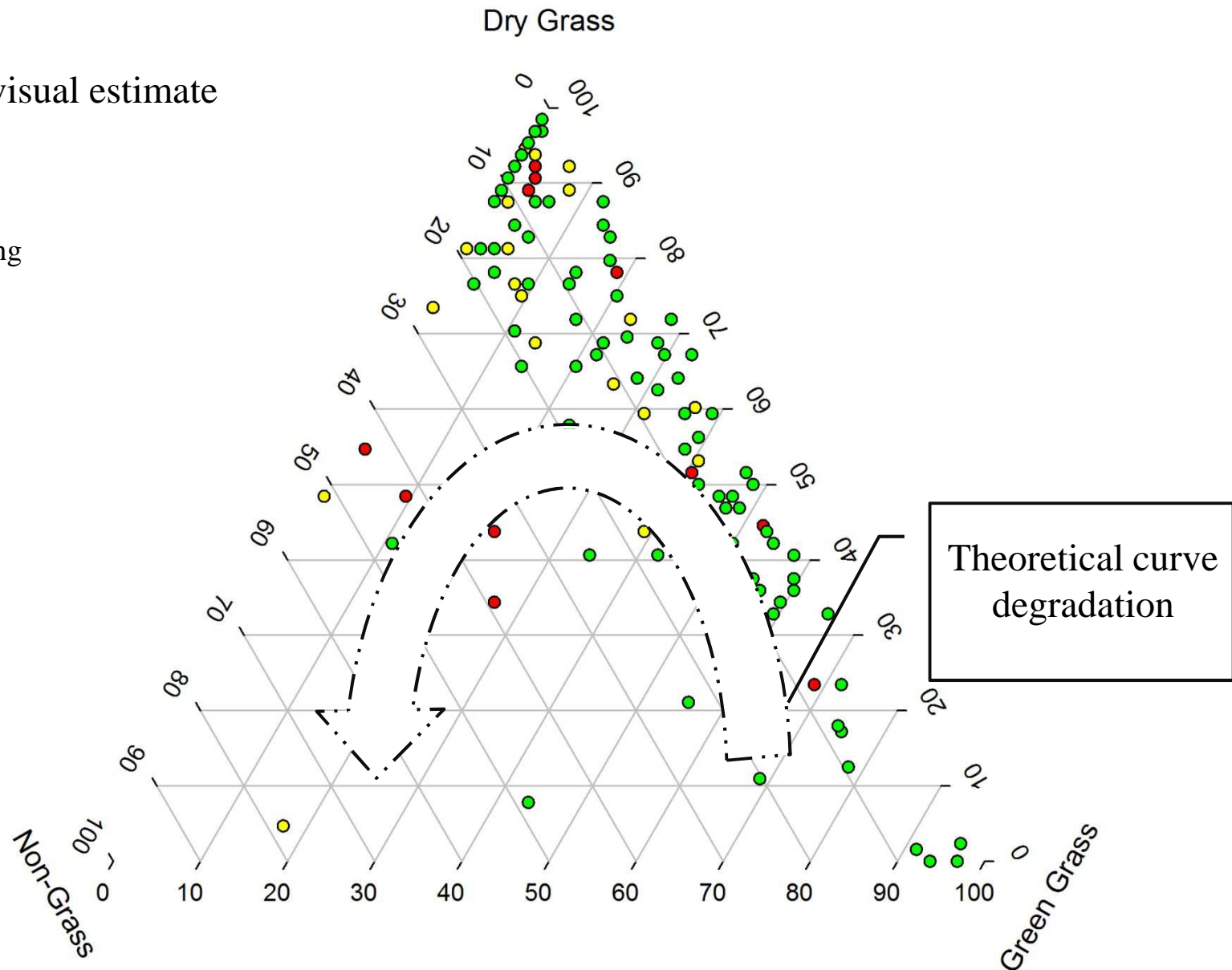
Extração das frações



Frações X estimativa de stand

Stand by visual estimate

- Adequate
- Medium
- Degradeting



Desafios/opportunidades para a aplicação de VANTs em agricultura

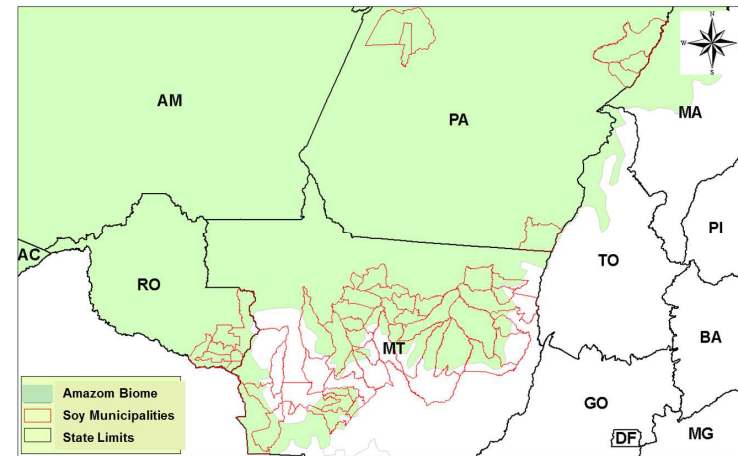
1) Pastagem:

- Auxílio na avaliação de degradação das pastagens – obtenção de frações de vegetação verde, vegetação seca e solo exposto de grandes áreas e com custo reduzido.

Moratória da Soja

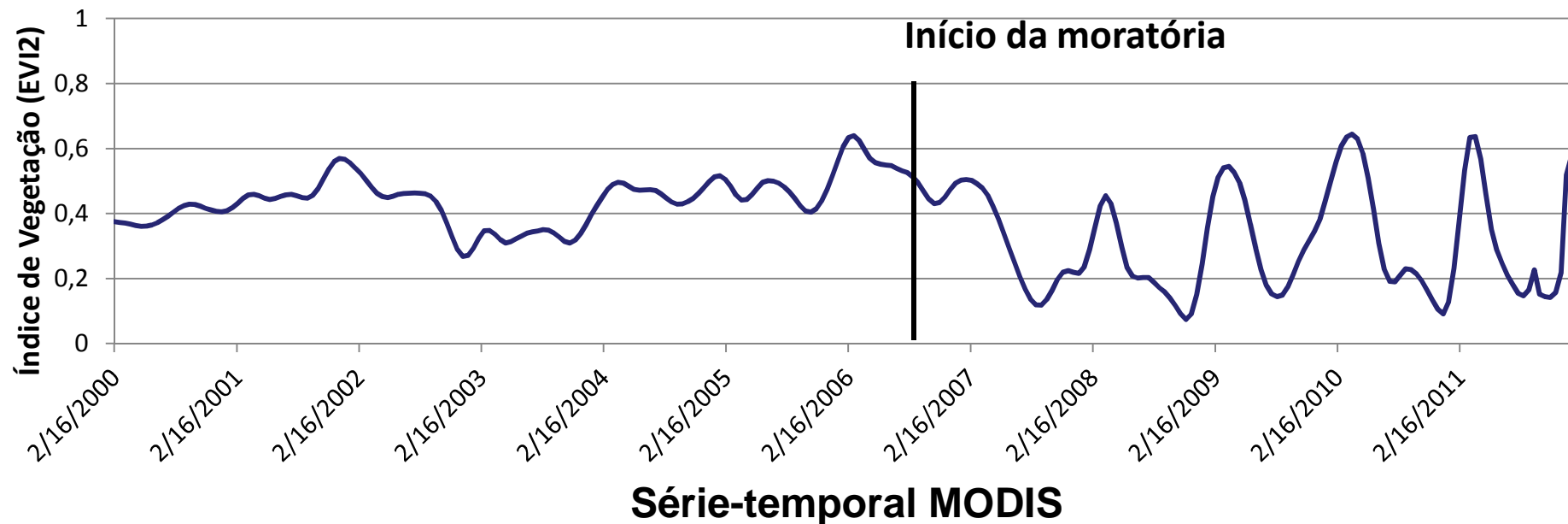
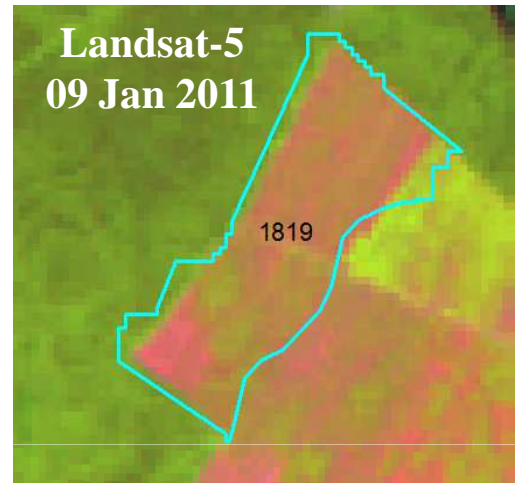
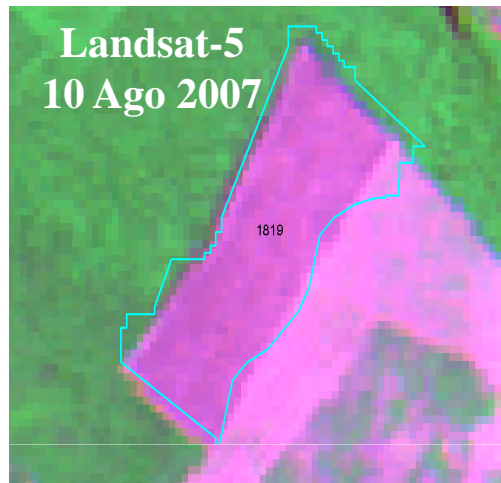
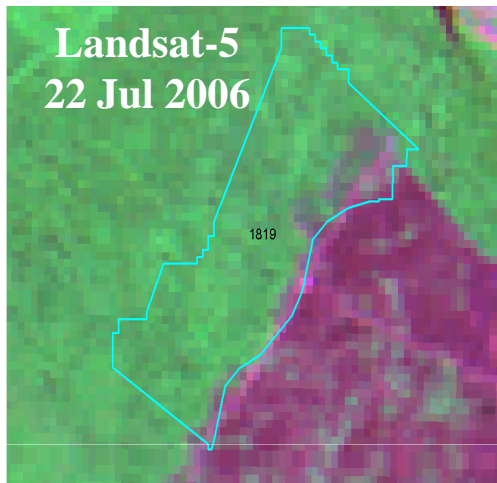


- Amazônia Brasileira (4,2 Mkm²) e 553 municípios;
- 7.5% da soja brasileira é produzida no bioma Amazônia(1,9 Mha) em 53 municípios (98%);
- Desflorestamento na Amazônia Legal de 2007 a 2010 foi 39.026 km²;
- Desflorestamento em municípios de soja de 2007 a 2010 foi 4.862 km² (12.5%);
- A Moratória da Soja teve início em **julho de 2006.**

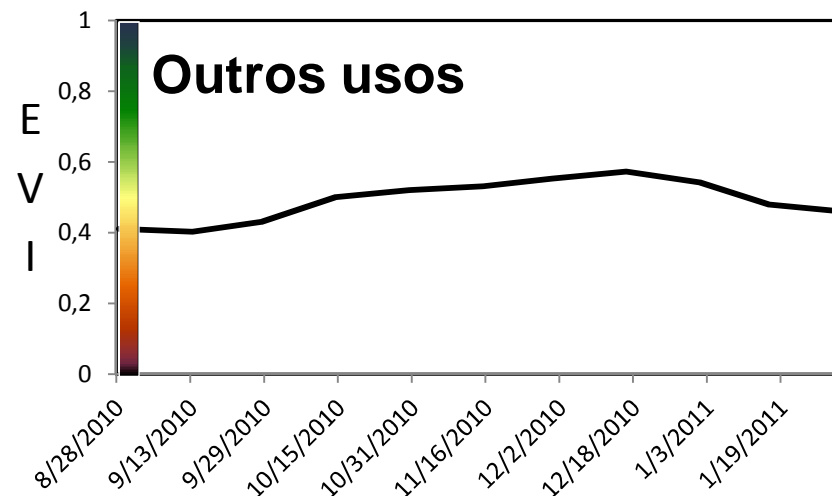
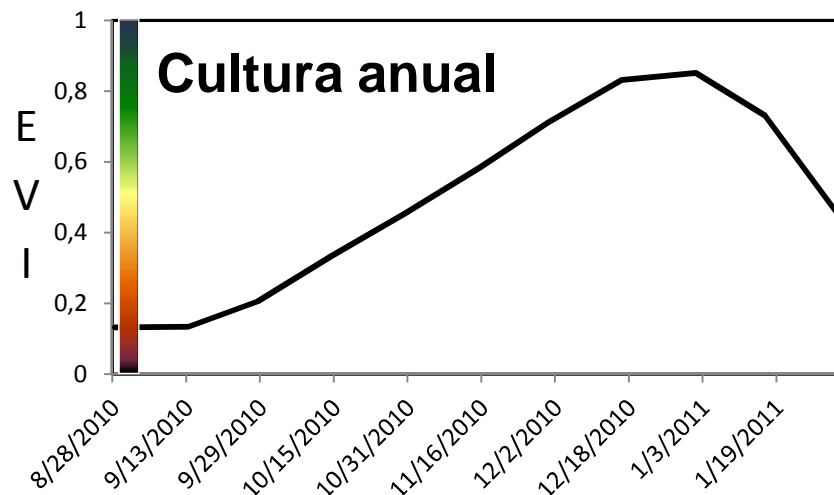


Avaliação da data do desflorestamento

Landsat & a Série-temporal MODIS



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



- **Todos polígonos do PRODES (>25 ha) são monitorados com imagens do sensor MODIS para verificar se existe 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.**

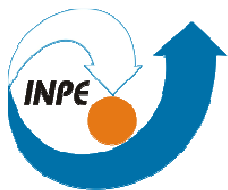
Rudorff, B.F.T.; Adami, M.; Aguiar, D.A.; Moreira, M.A.; Mello, M.P.; Fabiani, L.; Amaral, D.F.; Pires, B.M. The Soy Moratorium in the Amazon Biome Monitored by Remote Sensing Images. *Remote Sens.* 2011, 3, 185-202.

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.

Desafios/opportunidades para a aplicação de VANTs em agricultura

1) Soja:

- Fiscalização/monitoramento de plantio de soja em áreas desmatadas → redução de custos em relação ao uso de aviões.
- Autonomia dos VANTs (?) → grandes distâncias.



Obrigado

Outras Aplicações

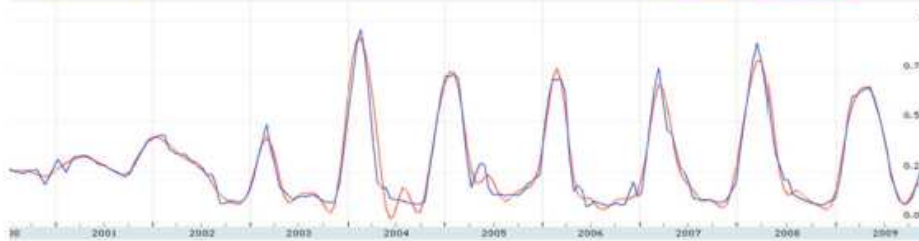
Virtual Laboratory of
Remote Sensing Time-Series

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

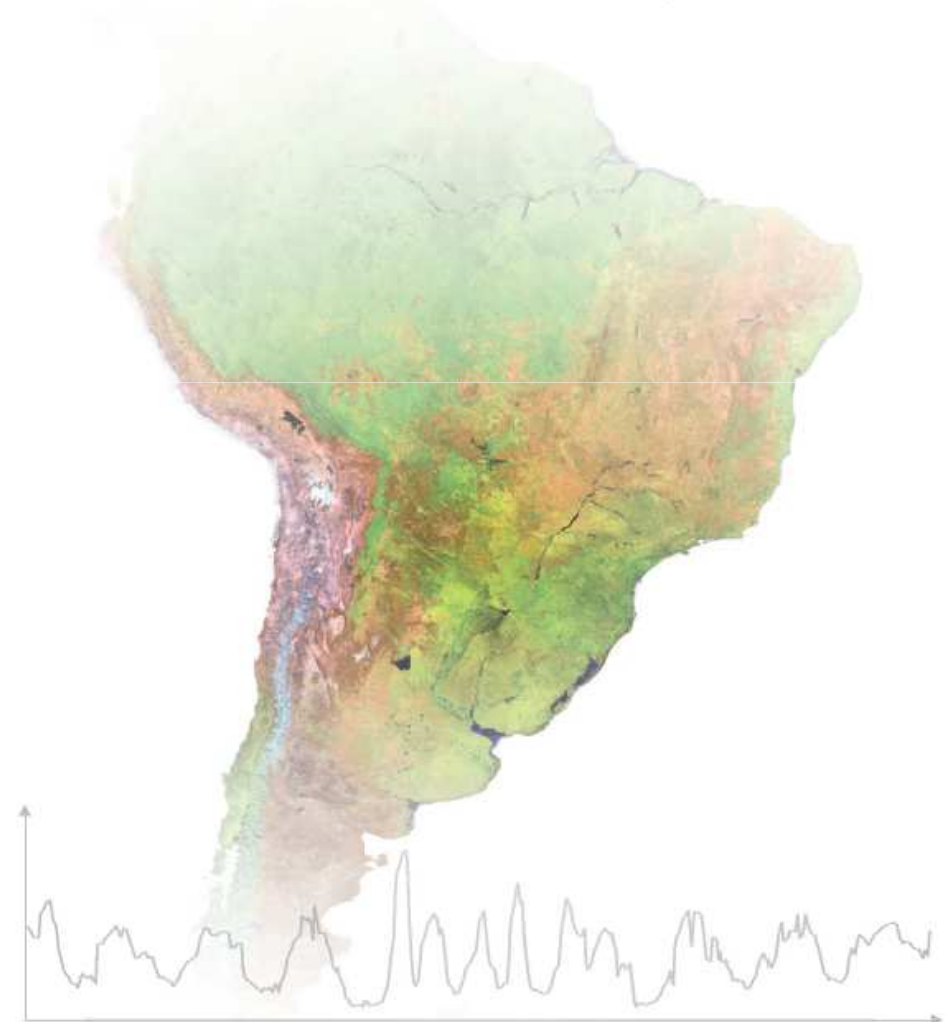


elevação salvar favoritos perfil sair



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

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



Visualization of time-series from the MODIS sensor

Time-series of MODIS¹ 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 laboratory² 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>)².

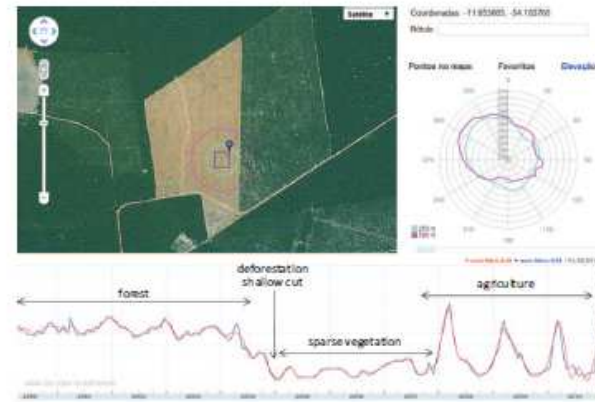
With a minimum of technical knowledge about vegetation dynamics it is possible to retrieve the land use and land cover change history for a given pixel. The figures presented next provide interpreted examples of the land use and land cover change based on the temporal variation of the vegetation index.

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

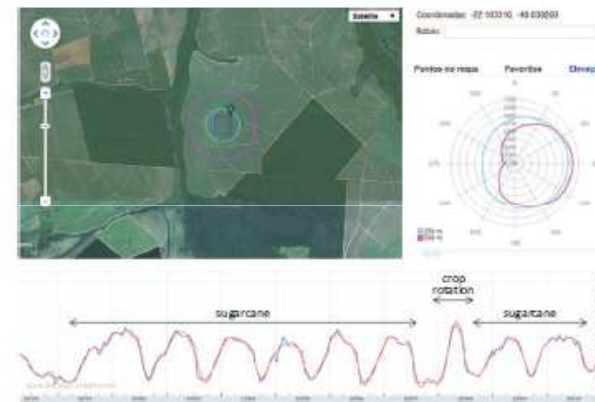
www.dsr.inpe.br/laf/series

¹Images 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.

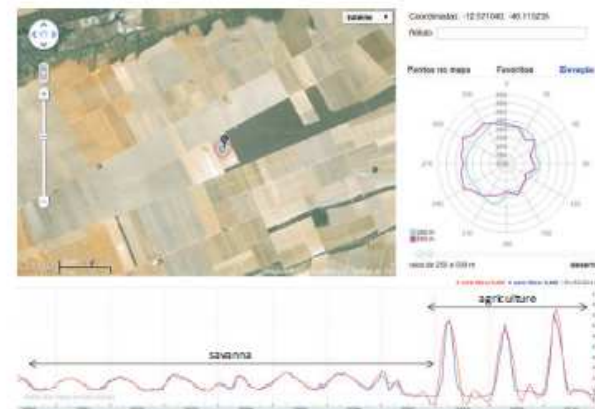
²A detailed description about the Virtual Laboratory of Remote Sensing Time-Series and the data filtering procedure can be found in: Freitas, R.M., Arai, E., Adami, M., Ferreira, A. S., Sato, F. Y., Shimabukuro, Y.E., Rosa, R. R., Anderson, L. O., Rudorff, B. F. T. Virtual laboratory of remote sensing 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.



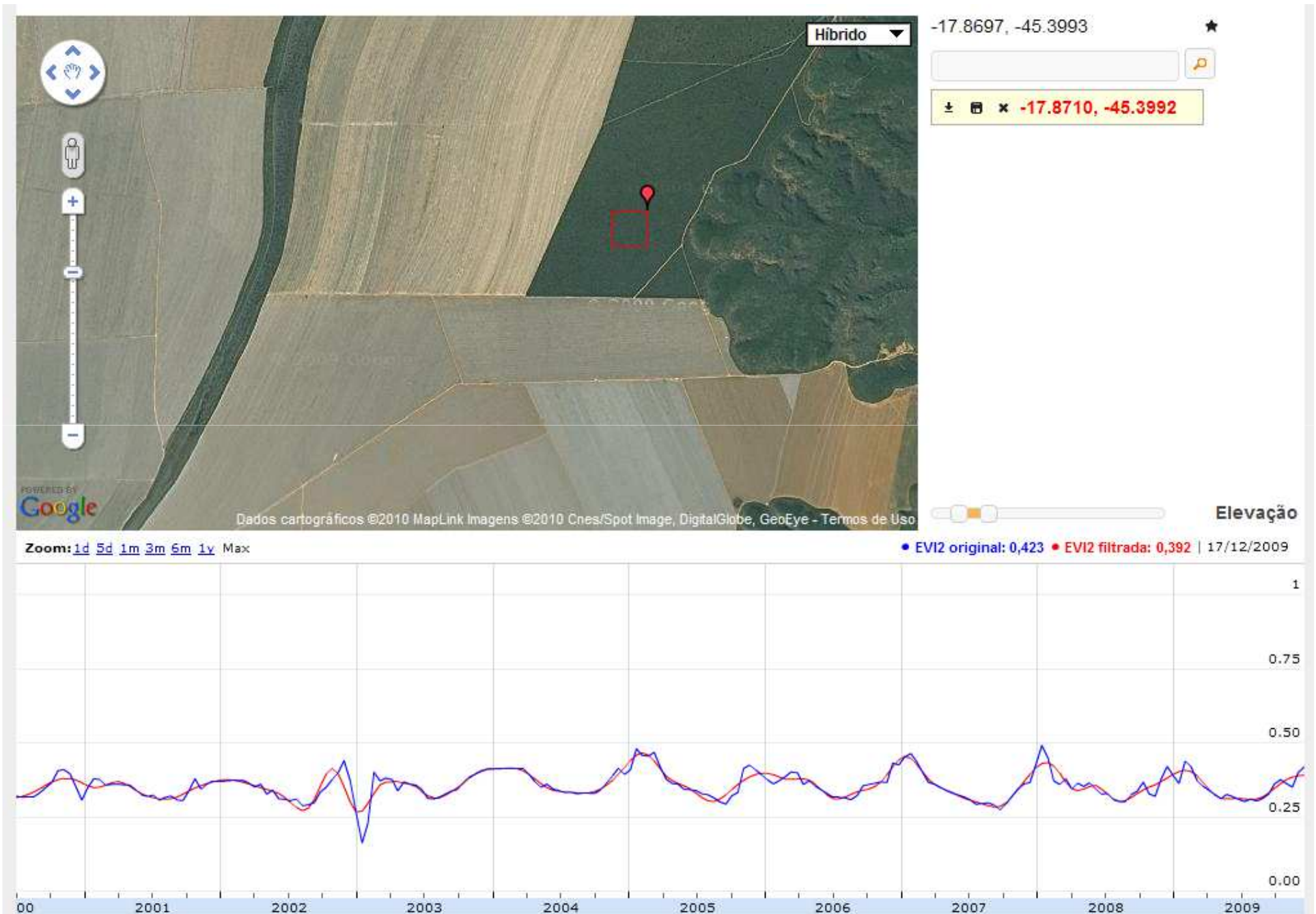
With some knowledge about the sugarcane crop growth cycle one can observe that the pixel (blue balloon in figure next) is from a sugarcane field planted in the beginning of 2001 that grew for a period of about 18 months prior to harvest in mid 2002. During the following five years the field was harvested 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

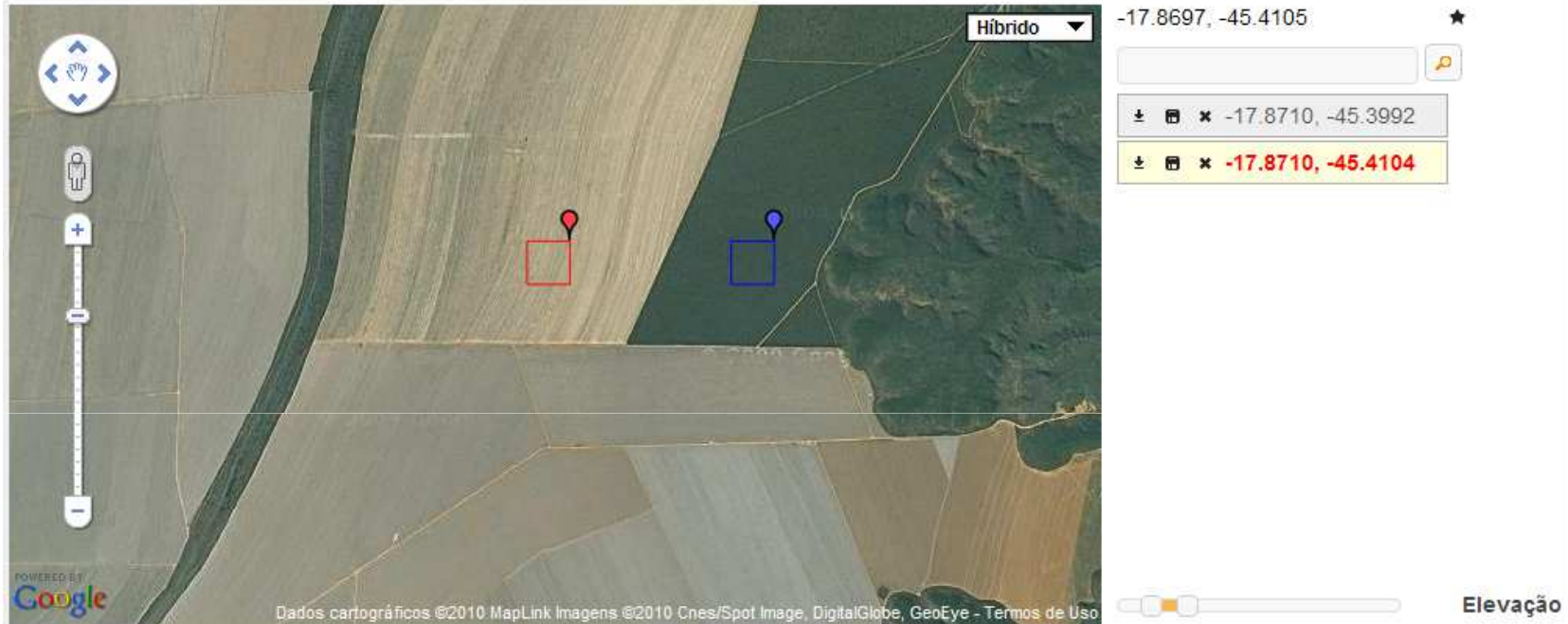
www.dsr.inpe.br/laf/series/





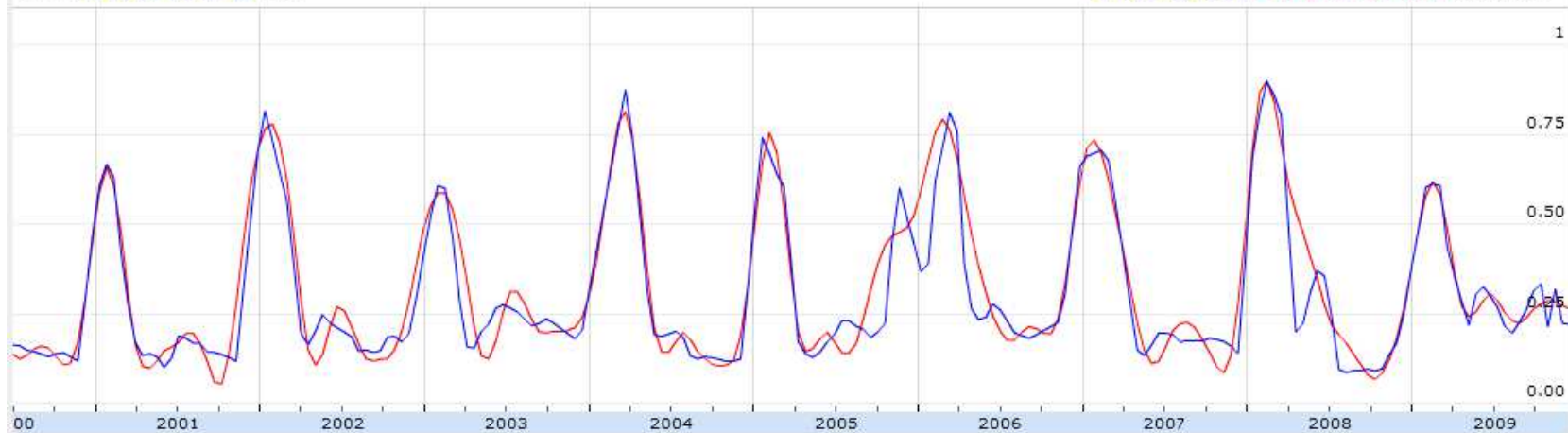
Gráficos de séries temporais MODIS

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

