



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Forest Monitoring Systems in Brazil

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Seminar for Climate Change and Forests
International Conference Hall – Waseda University, Japan
February 7th– 8th , 2013



Summary of Presentation

- Brazilian forest monitoring systems:
 - Annual wall-to-wall assessment of the gross deforestation rate
 - PRODES, Brazilian Legal Amazonia
 - Use of satellite imagery of moderate resolution (30 meters)
 - Annual wall-to-wall assessment of the forest degradation
 - DEGRAD/DETEX, Brazilian Legal Amazonia
 - Use of satellite imagery of moderate resolution (30 meters)
 - *Near* real time detection of deforestation and forest degradation
 - DETER, Brazilian Legal Amazonia
 - Use of satellite imagery of coarse resolution (250 meters)
- Present status



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Annual Wall-to-Wall Estimate of the Gross Deforestation Rate in Amazonia - PRODES



PRODES: Annual Rate of Gross Deforestation in Amazonia - Overview

Coverage: Wall-to wall

Frequency: Yearly

Integration period: Aug-Jul

Resolution – Landsat-class
(Landsat, CBERS, DMC, SPOT)

Method: Visual interpretation

Minimum mapping area: 6.25 ha

Delivery Schedule:

1st estimate -90% of previous
year, ~100 Scenes : November

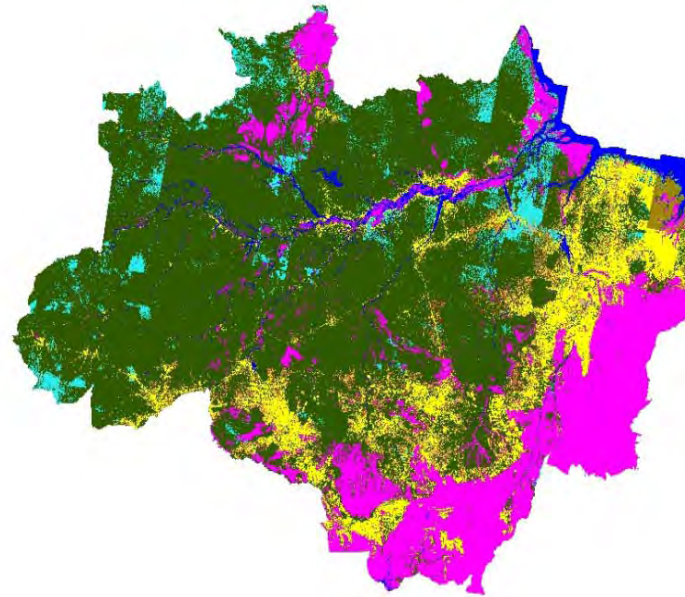
Complete map: April, next year

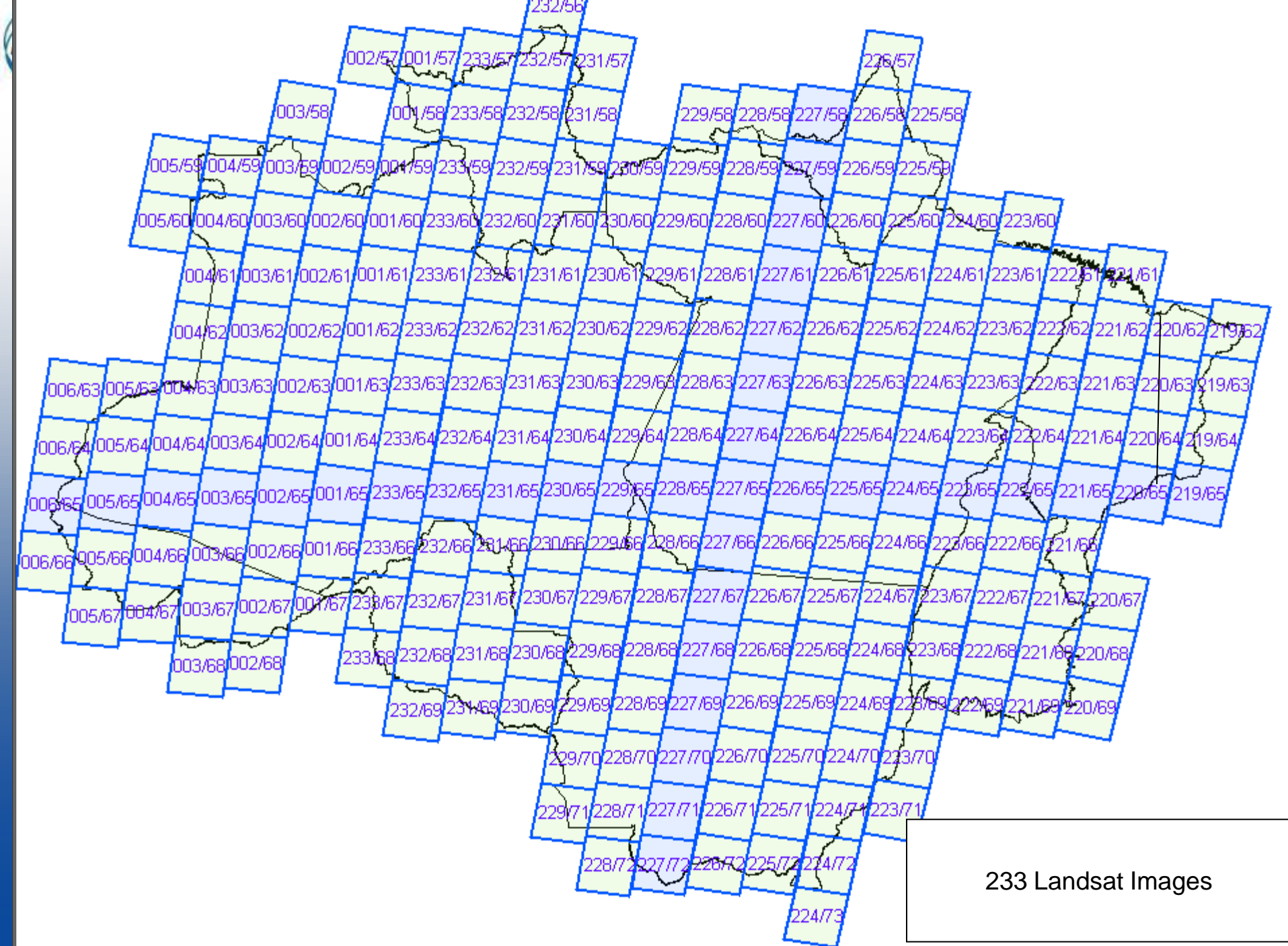
Brazilian Legal Amazon Region: 5 million km²

Original forest cover: 4 million km²

Present gross deforested area: 730.000 km²

Proportion of secondary forest: 19% (130.000 km²)





233 Landsat Images



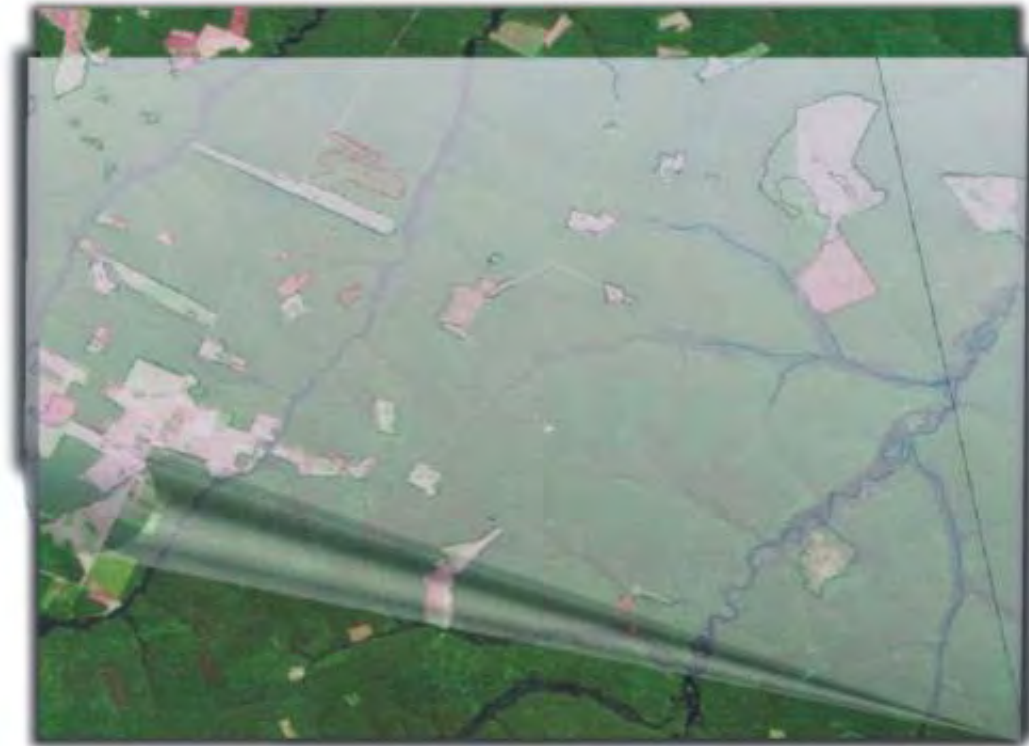
PRODES: Rate of Gross Deforestation in Amazonia – a Brief history

1988-2002 – Annual assessments on a regular basis

1:250.000 Landsat Color composites

Visual interpretation

Digital area calculation





PRODES: Rate of Gross Deforestation in Amazonia – a Brief history

Three bands color composite



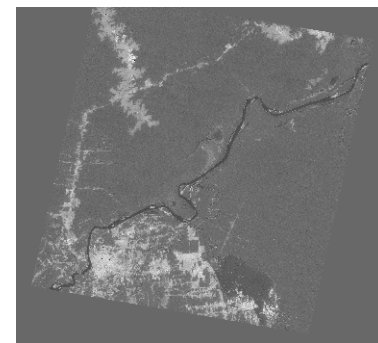
INPE's new development in the 90's

SPRING – Geographic Information Processing System

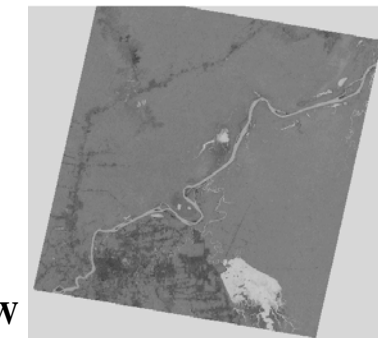
Features applied to PRODES:

- **Linear Mixing Model**
- **Image Segmentation**
- **Object Oriented Classification**
- **Raster and Vector Edition**

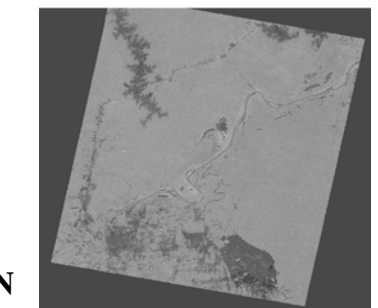
SOIL



SHADOW



GREEN VEGETATION



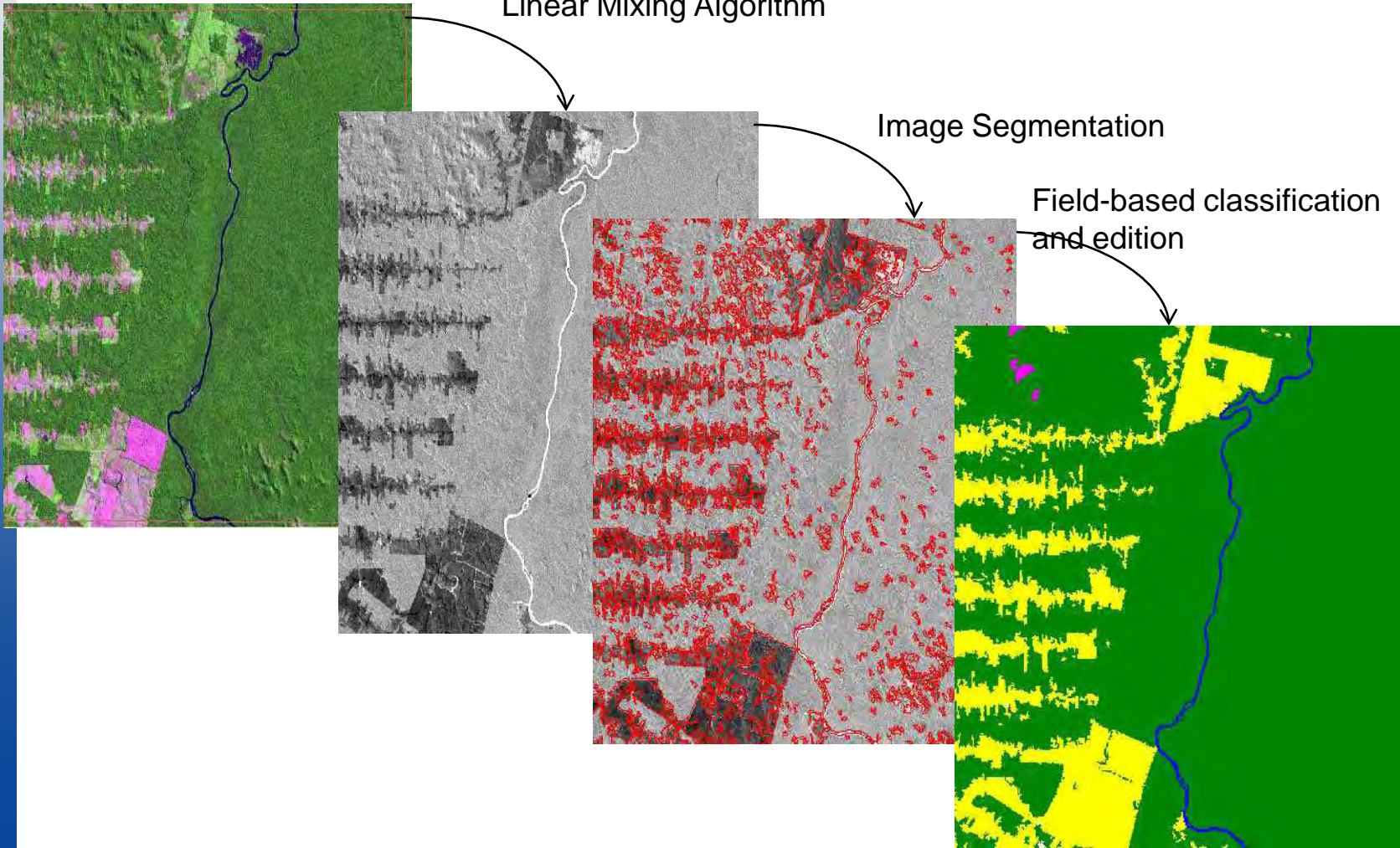
PRODES: Rate of Gross Deforestation in Amazonia – a Brief history

1997-2005 – SPRING based digital Landsat image analysis

Linear Mixing Algorithm

Image Segmentation

Field-based classification
and edition



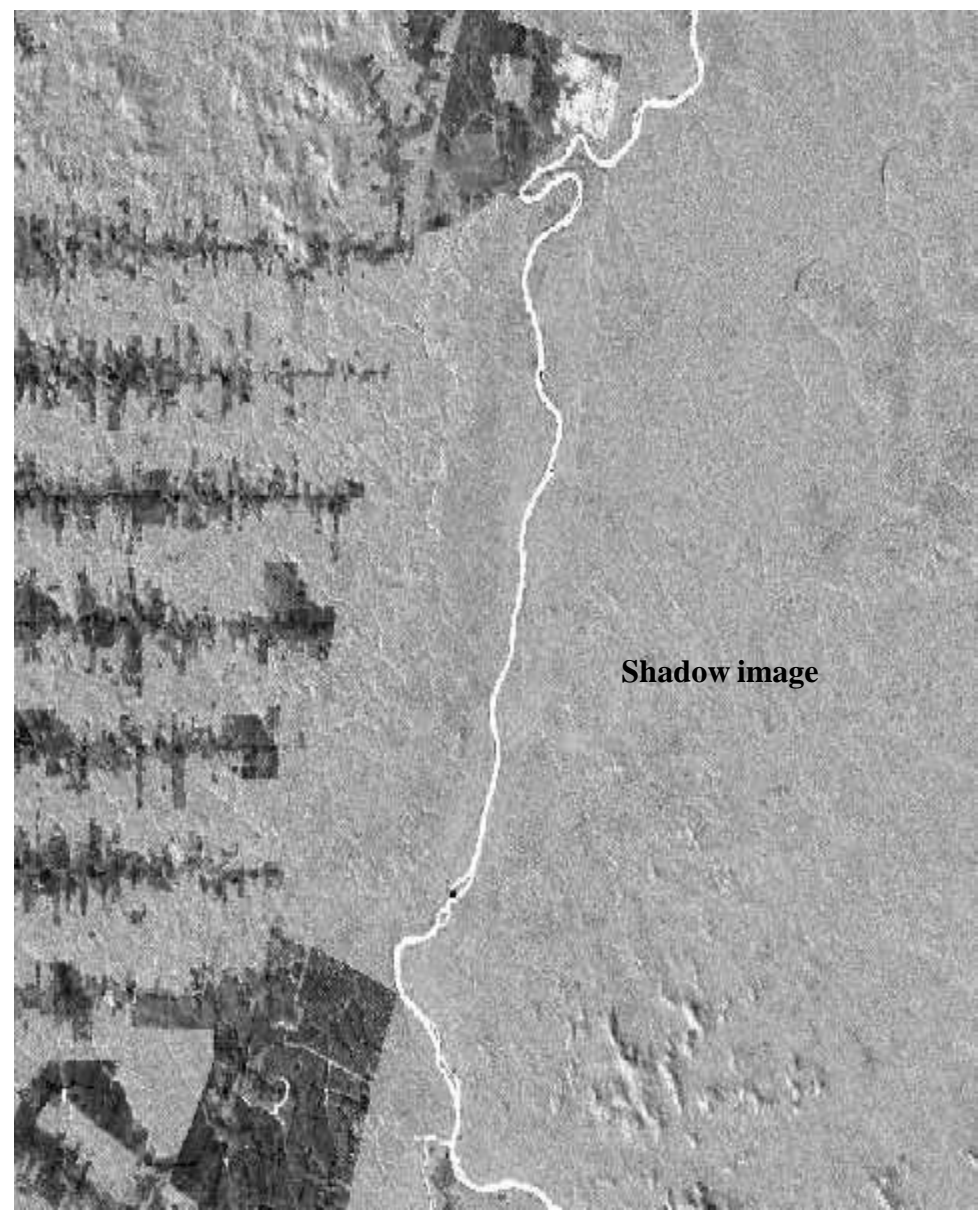
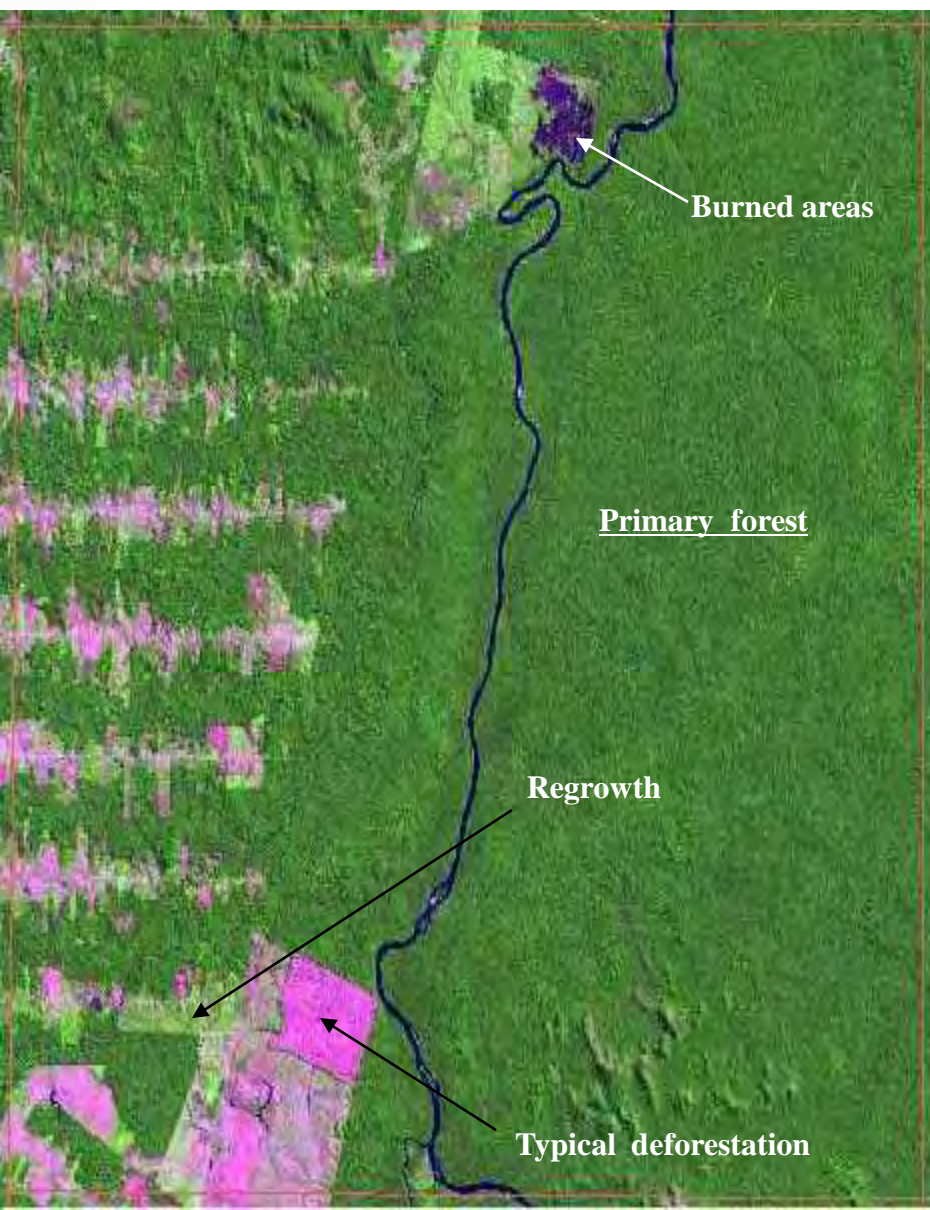
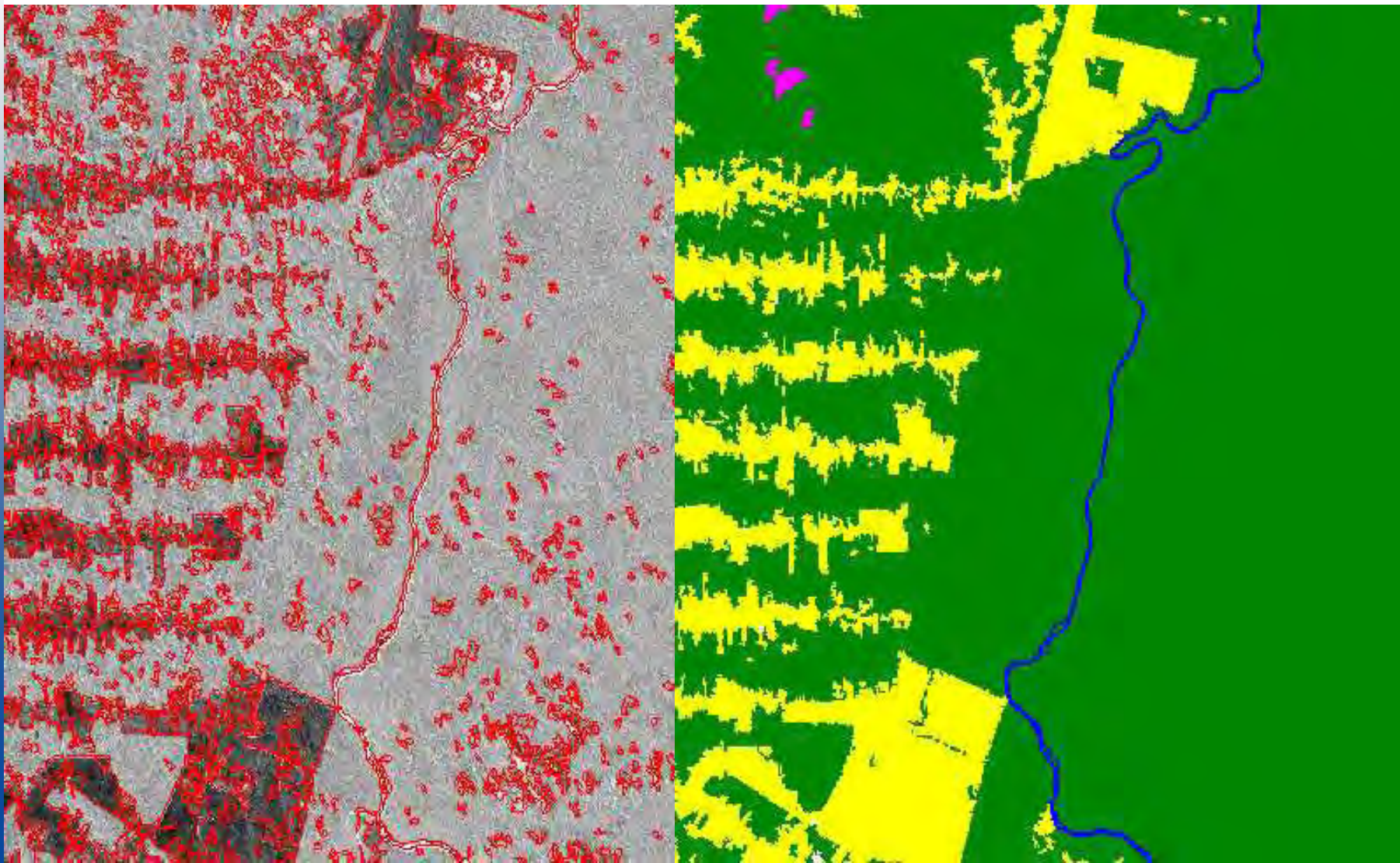
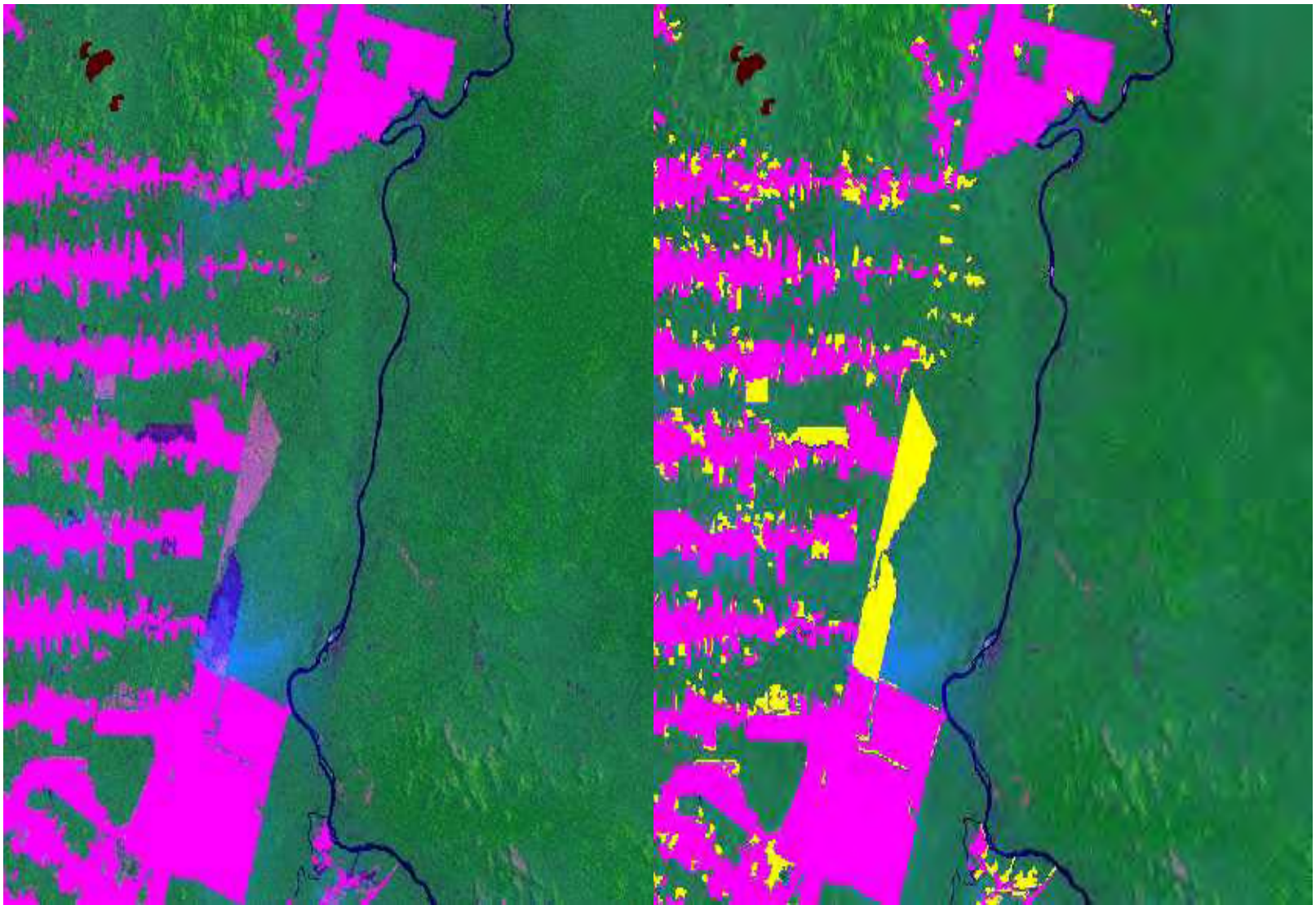


Image segmentation and classification





Change detection with masking of previous deforestation





PRODES: INPE's Amazon Monitoring Program

A brief history

2005-Present: Visual interpretation in TerraAmazon GDBM Platform

TerraAmazon overview:

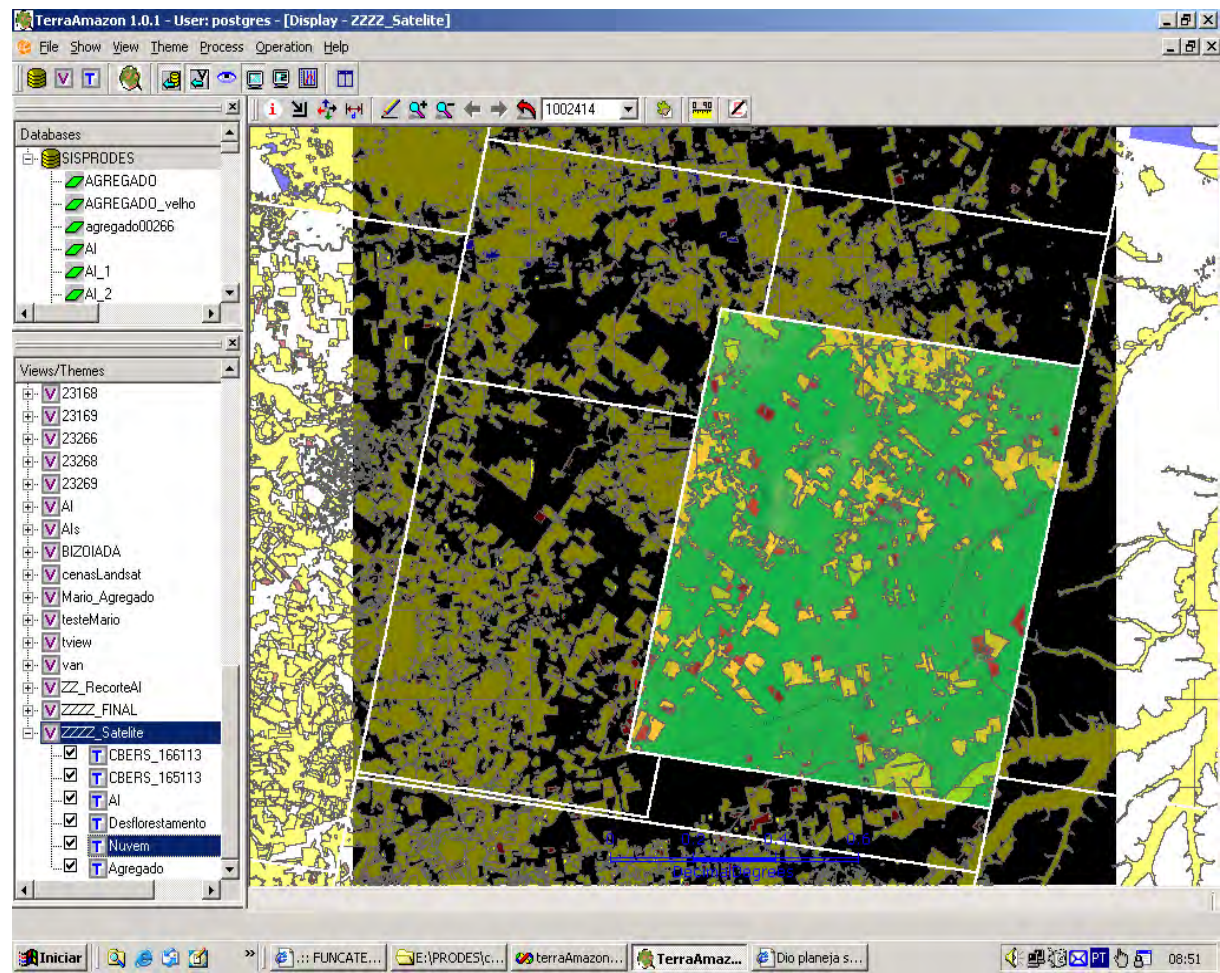
Allows multisource and multitemporal data

Allows multiple interpreters

Real-time GDB update

Lock-in lock-out control

TerraLib open code



PRODES: Rate of Gross Deforestation in Amazonia – a Brief history

2005-Present: Visual interpretation in TerraAmazon GDBM Platform

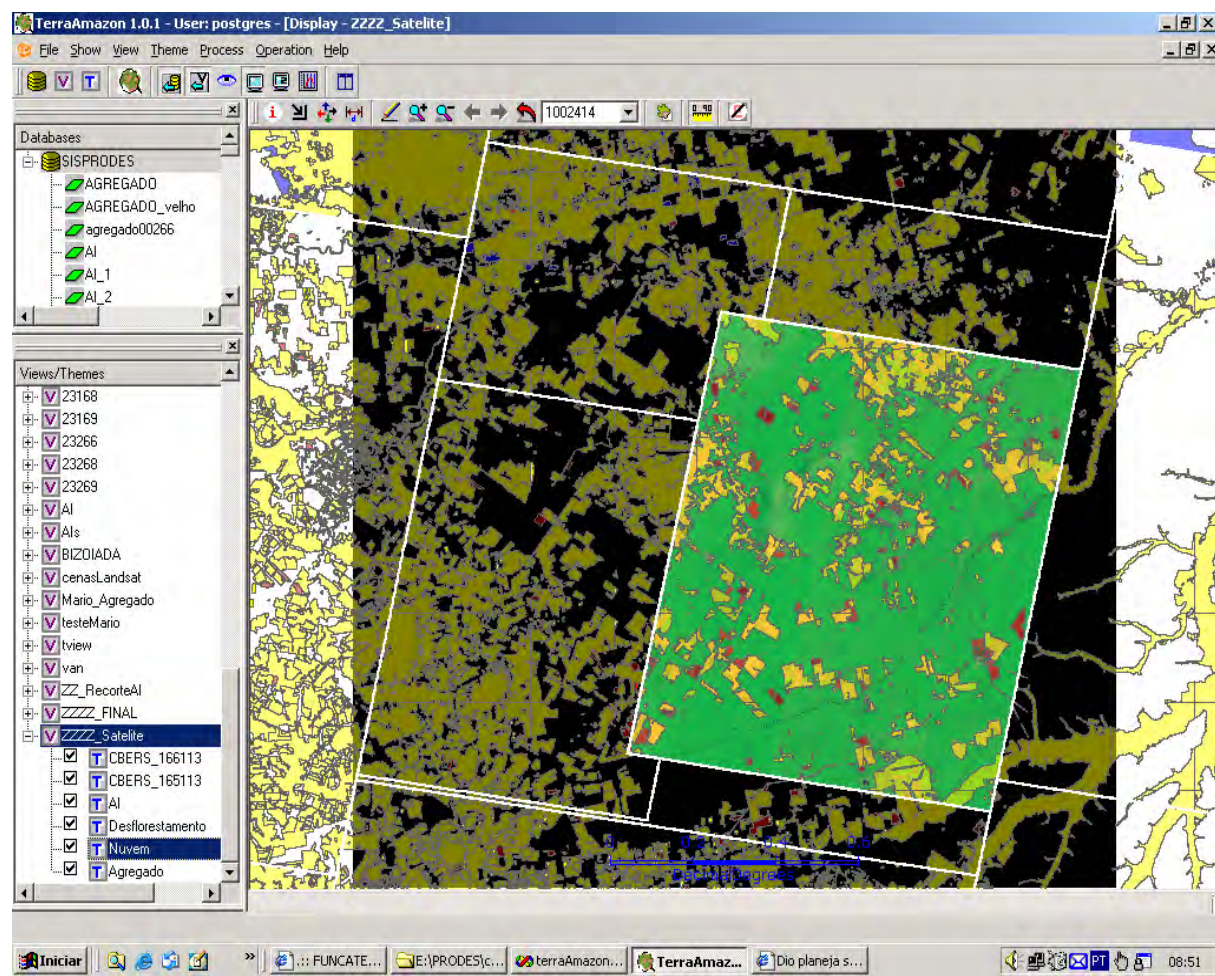
TerraAmazon overview:

Tbyte level GDB

• Interpretation time:

(SPRING) DIP+Ed: 20 hs

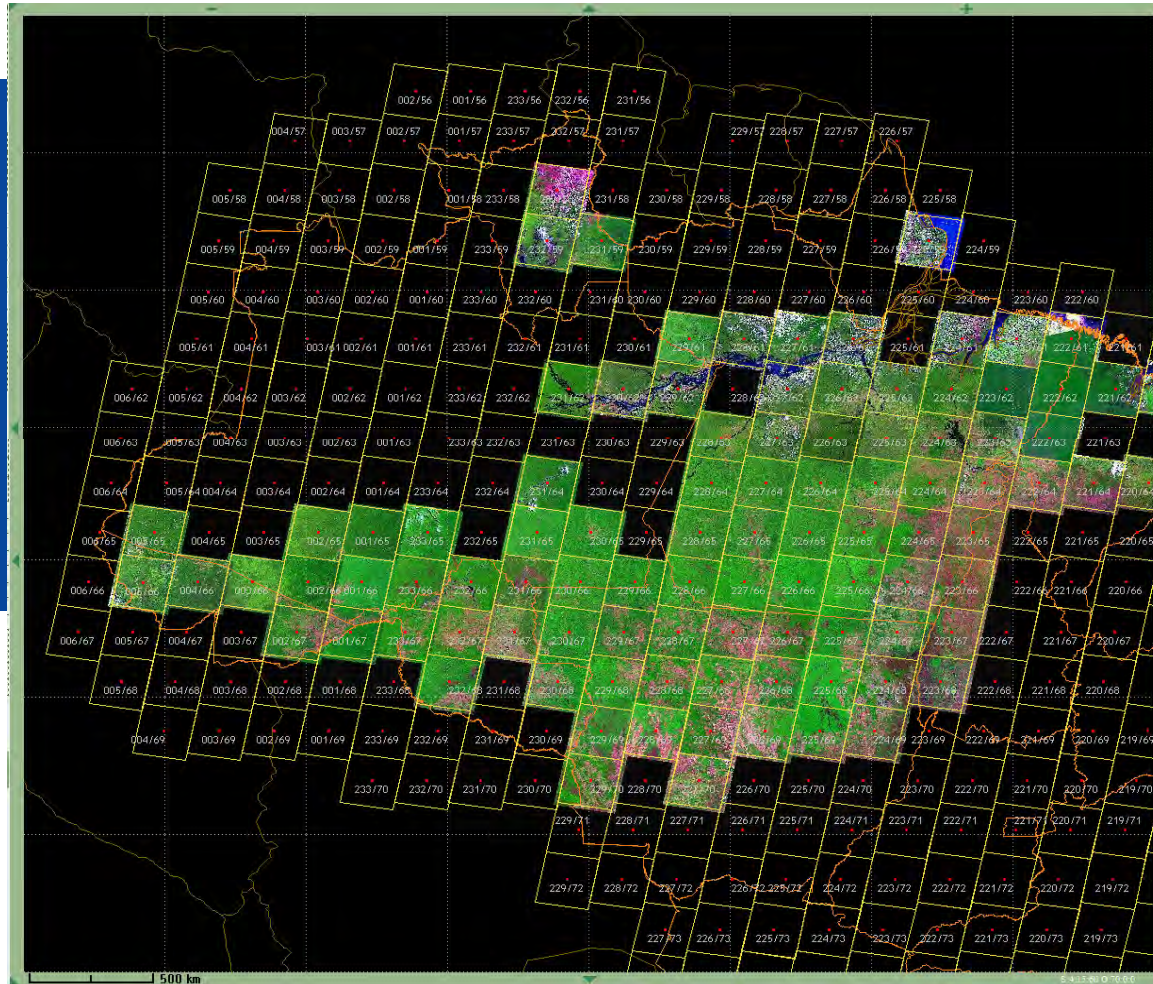
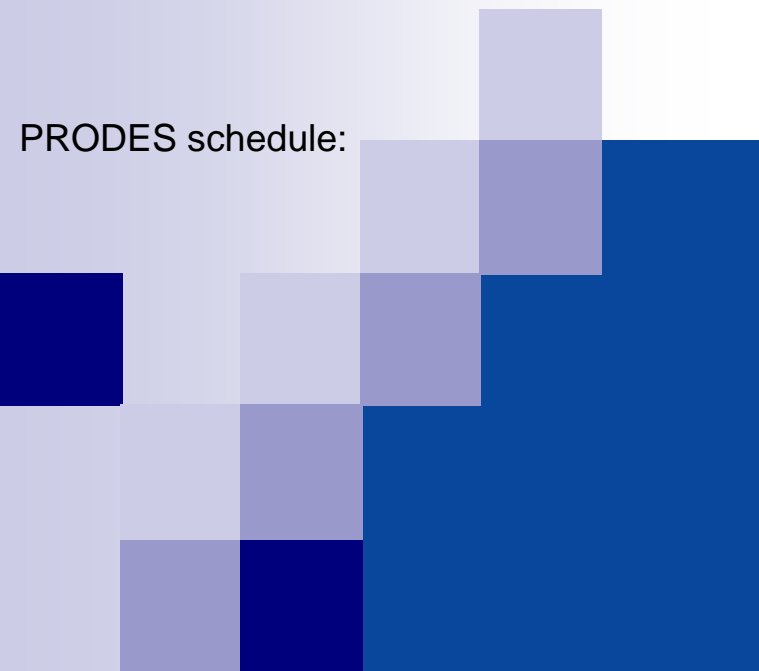
(TerraAmazon) VI: 5-10 hs





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PRODES schedule:



1st Semester:

April :Complement of 2011 inventory

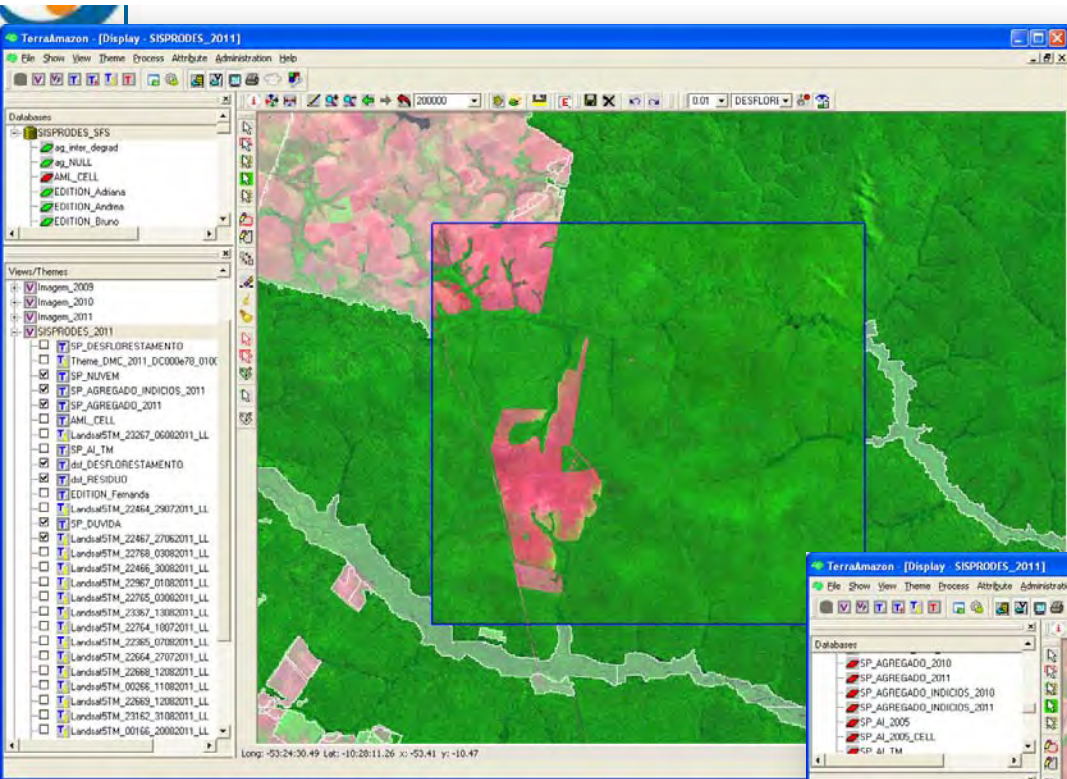
2nd Semester

First deforestation estimate

Data Acquisition: Jun-Sep

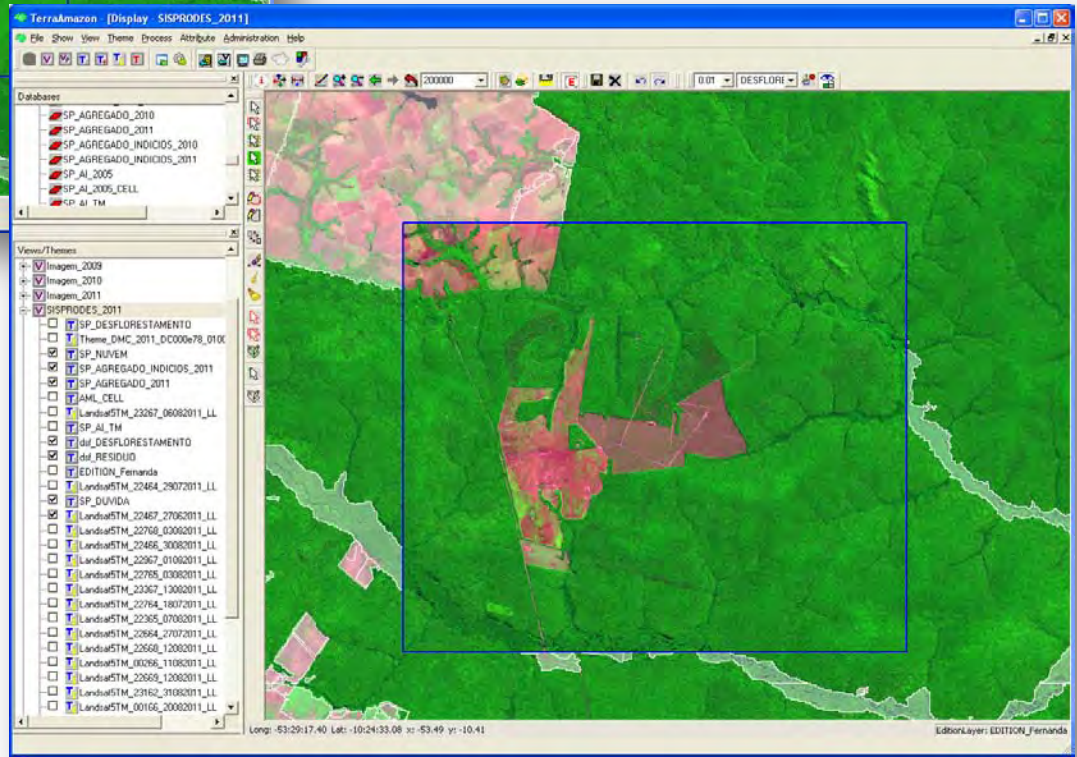
Product delivery: November

o 53 30 38 s 10 24 45 - Peixoto de Azevedo/MT - Landsat 225/67

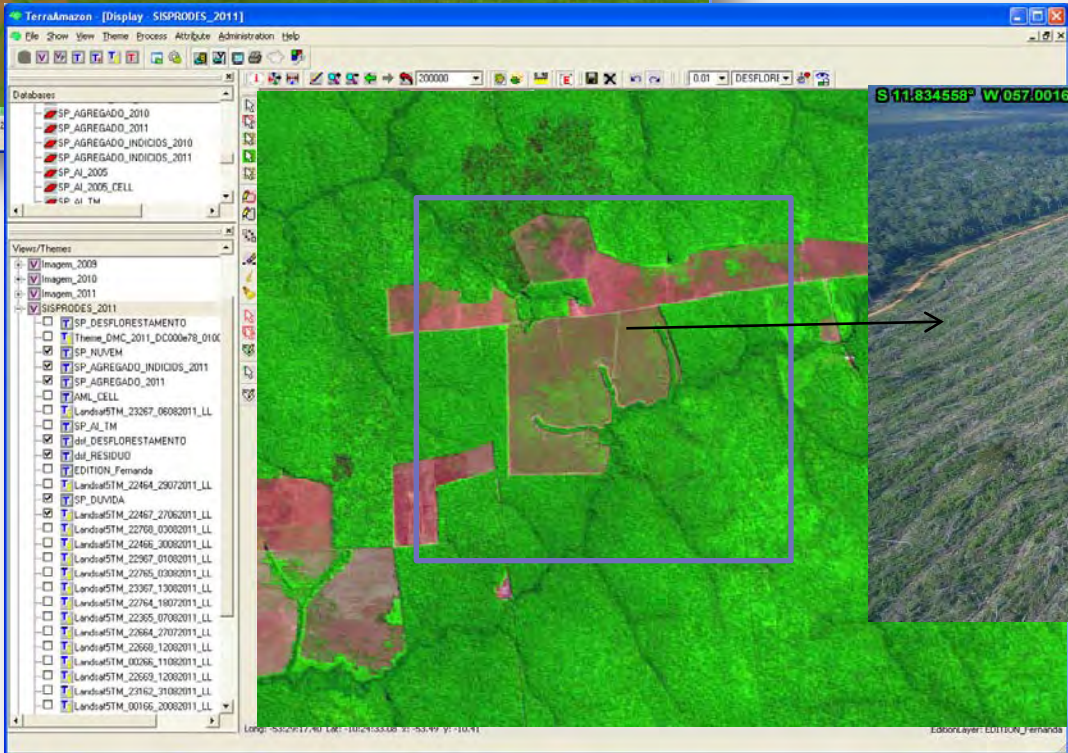
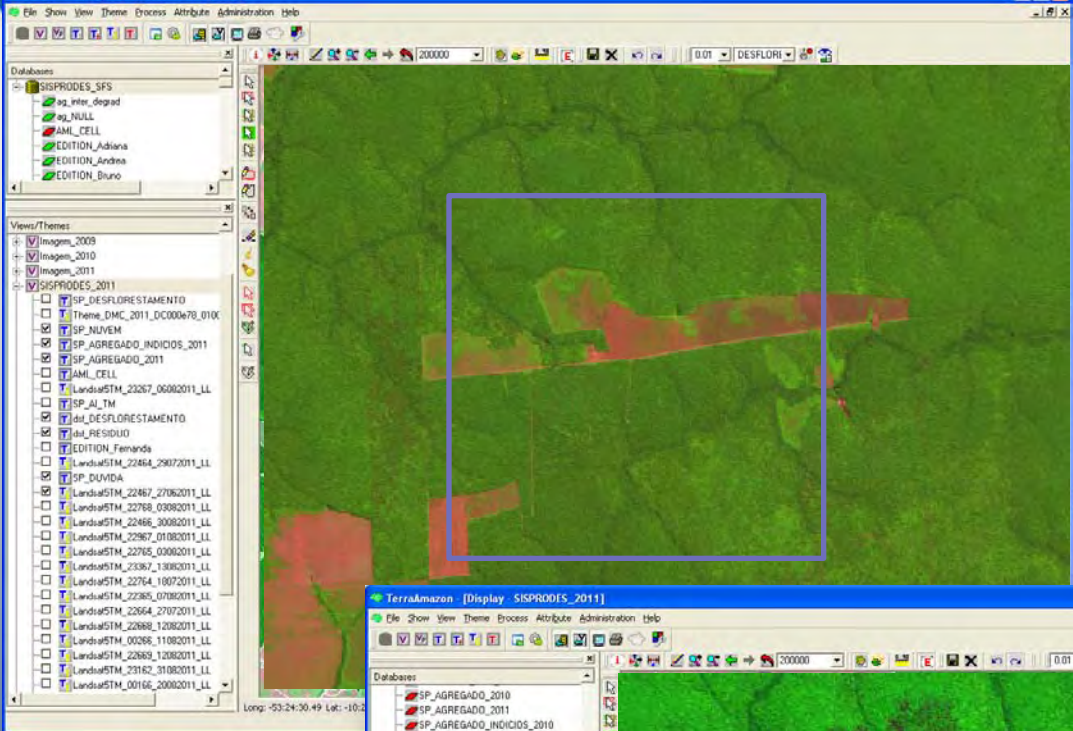


Set/2010

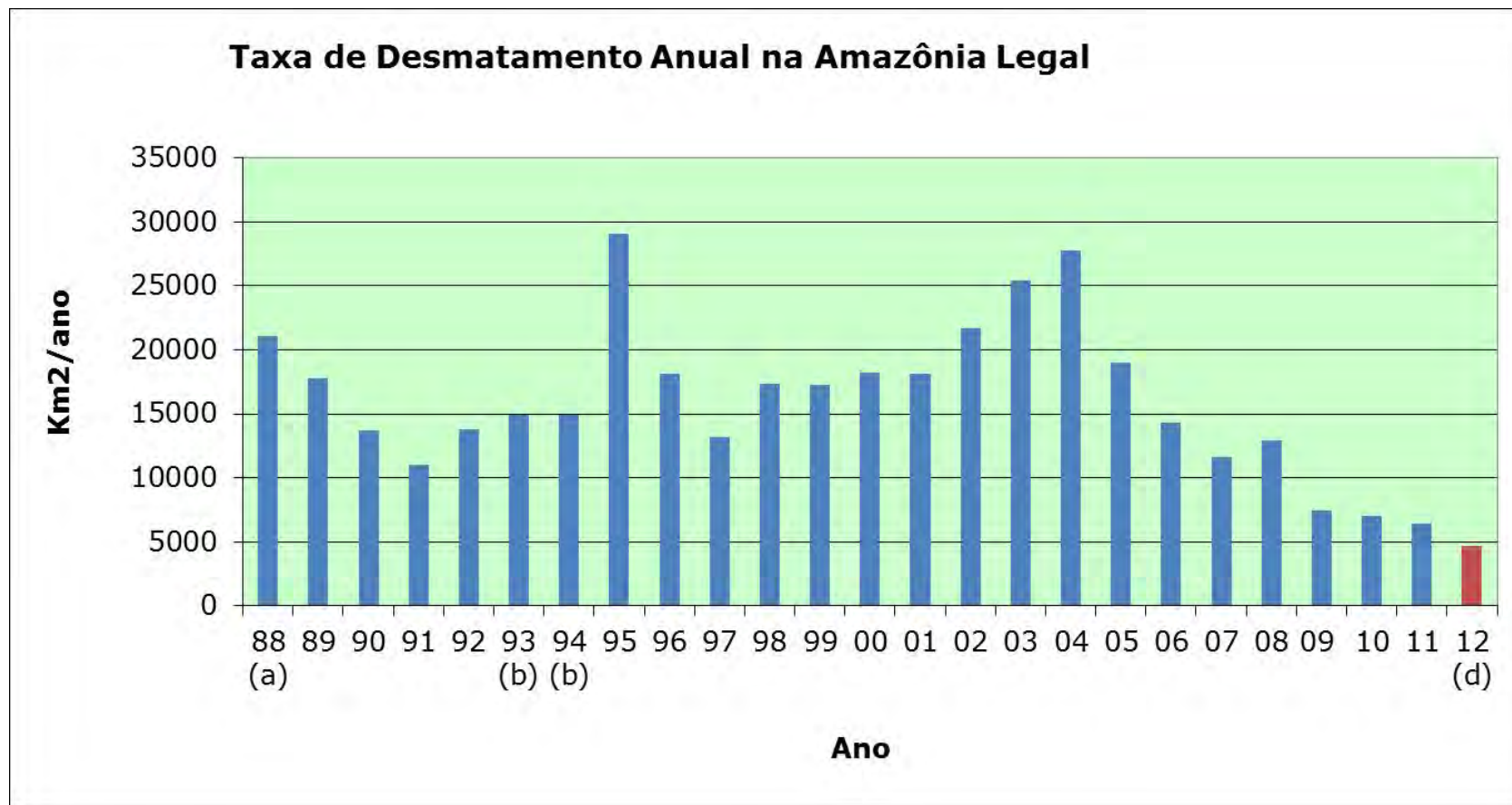
Jul/2011



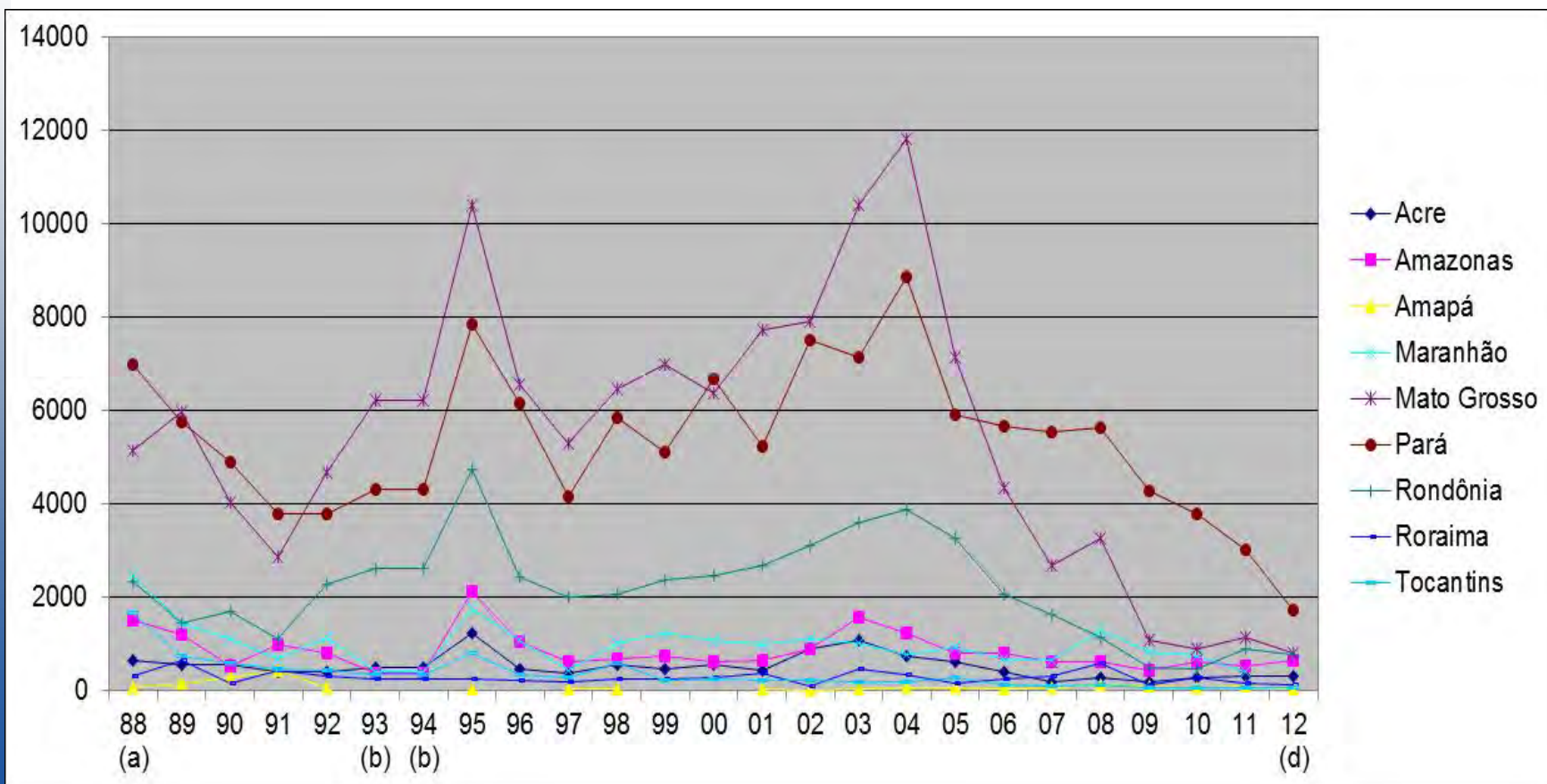
o 57 00 05 s 11 49 48 - Porto dos Gaúchos/MT - Landsat 227/68



Annual Gross Deforestation Rates from 1988 to 2012 (km²/year)



Annual Deforestation Rate per State in Amazonia 1988 – 2012 (km²/year)





PRODES: Rate of Gross Deforestation in Amazonia

– Internet Access

Full access to source images, maps and statistics

The screenshot shows a Mozilla Firefox browser window with the address bar displaying <http://www.obt.inpe.br/prodes/>. The page is the official website of the PRODES project, managed by the Coordenação-Geral de Observação da Terra - OBT, under the Ministério da Ciência e Tecnologia. The page features a navigation menu with links to Home OBT, Projetos, Pós-Graduação, Satélites, Imagens, Softwares, and Publicações. The main content area is titled "PROJETO PRODES MONITORAMENTO DA FLORESTA AMAZÔNICA BRASILEIRA POR SATÉLITE" and includes a section for "Apresentação Geral". This section explains that since 1988, INPE has been producing annual deforestation estimates from Landsat images. It lists the methodology and provides a list of annual data entries from 2000 to 2005, including the total confirmed deforestation area for each year. The left sidebar contains links to "PRODES DIGITAL" (Apresentação Geral, Taxas Anuais desde 1988, Metodologia, Apresentação Taxa PRODES 2010 (novo), Apresentação em Slides do PRODES, Dados por Município, Dados por Unidades de Conservação, Banco de Dados PRODES, Seminário PRODES 2005 e 2010, Relatório PRODES 2008) and "PRODES ANALÓGICO" (Relatórios). The bottom of the browser window shows the Windows taskbar with the Start button and several open applications, including Windows Explorer, Microsoft Word, and Mozilla Firefox. The system clock indicates the time is 7:43 PM.

Projeto - PRODES - Mozilla Firefox

File Edit View History Bookmarks Tools Help

<http://www.obt.inpe.br/prodes/>

Most Visited Getting Started Latest Headlines

Absolute Classic Rock - Digital Radio UK... Projeto - PRODES

Ministério da Ciência e Tecnologia

Destaques do governo

Coordenação-Geral de Observação da Terra - OBT

Home OBT | Projetos | Pós-Graduação | Satélites | Imagens | Softwares | Publicações

PRODES DIGITAL

- Apresentação Geral
- Taxas Anuais desde 1988
- Metodologia
- **Apresentação Taxa PRODES 2010 (novo)**
- Apresentação em Slides do PRODES
- Dados por Município
- Dados por Unidades de Conservação
- Banco de Dados PRODES
- Seminário PRODES 2005 e 2010
- Relatório PRODES 2008

PRODES ANALÓGICO

Relatórios:

PRODES Analógico Done

PROJETO PRODES
MONITORAMENTO DA FLORESTA AMAZÔNICA BRASILEIRA POR SATÉLITE

Apresentação Geral

Desde 1988, o INPE vem produzindo as [Taxas Anuais](#) do desflorestamento da Amazônia Legal. A partir do ano de 2002, estas estimativas estão sendo produzidas por classificação digital de imagens seguindo a "[Metodologia Prodes](#)". A principal vantagem deste procedimento está na precisão do geo-referenciamento dos polígonos de desflorestamento, de forma a produzir um banco de dados geográfico multitemporal. A partir dos incrementos de desflorestamento identificados em cada imagem, as taxas anualizadas são estimadas para a data de 1/agosto do ano de referência. Os dados tabulares mais recentes publicados pelo INPE são:

- [Dados de entrada 2000-2010](#): Dados de entrada usados para o cálculo das estimativas anuais.
- [Ano 2001-2002](#): Taxas de desflorestamento obtidas por classificação de 161 imagens LANDSAT. A taxa total confirmada pelo INPE para o período de Agosto de 2001 a Agosto de 2002 é de 21.651 km².
- [Ano 2002-2003](#): Taxas de desflorestamento obtidas por classificação de 191 imagens LANDSAT. A taxa total confirmada pelo INPE para o período de Agosto de 2002 a Julho de 2003 é de 25.396 km².
- [Ano 2003-2004](#): Taxas de desflorestamento obtidas por classificação de 207 imagens LANDSAT. A taxa total confirmada pelo INPE para o período de Agosto de 2003 a Julho de 2004 é de 27.772 km².
- [Ano 2004-2005](#): Taxas de desflorestamento obtidas por classificação de 211 imagens LANDSAT e de outros satélites quando houver cobertura de nuvens. As imagens de origem de um satélite (de dados brutos) são recebidas...

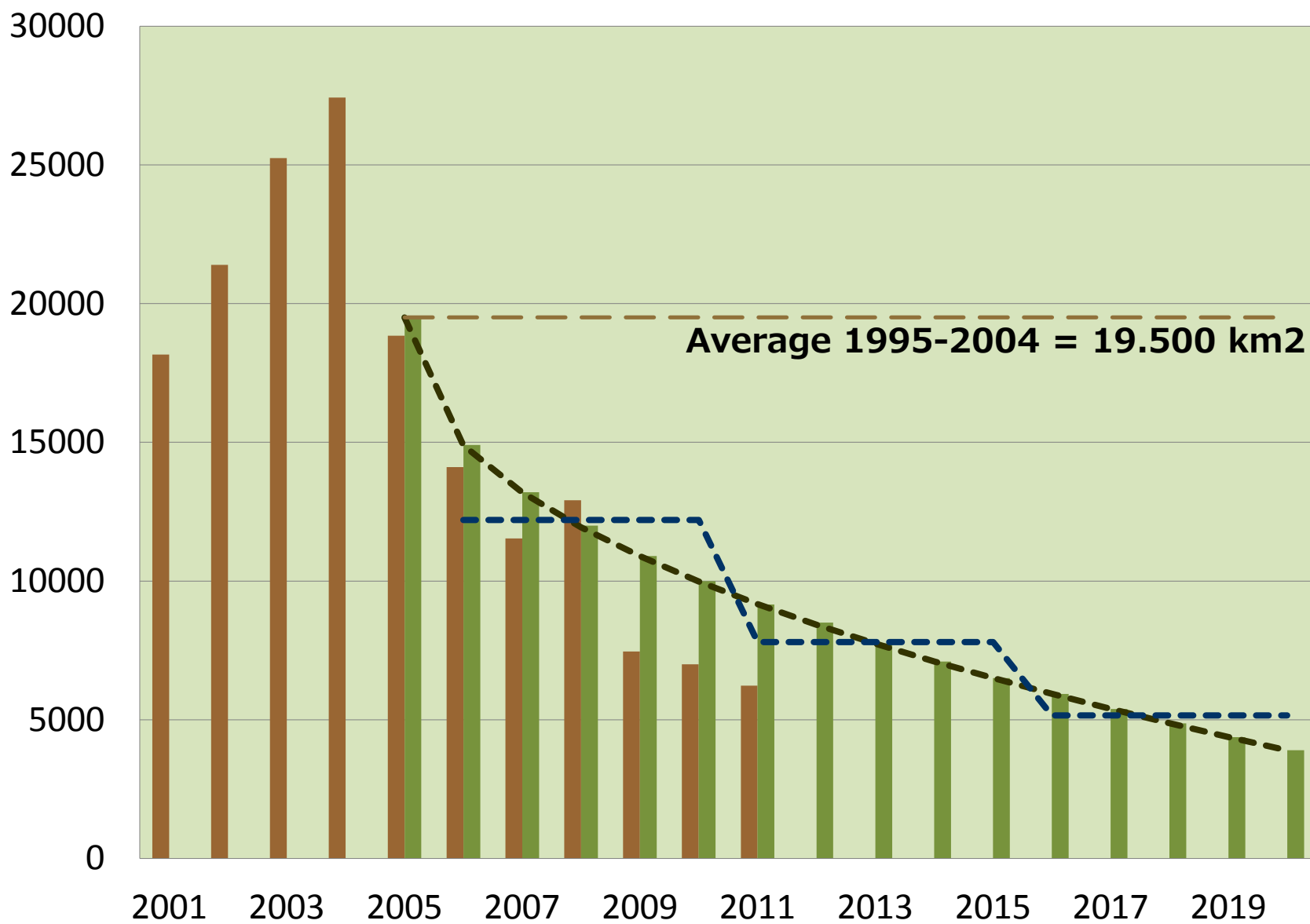
CT BRASIL

IBAMA MMA

start

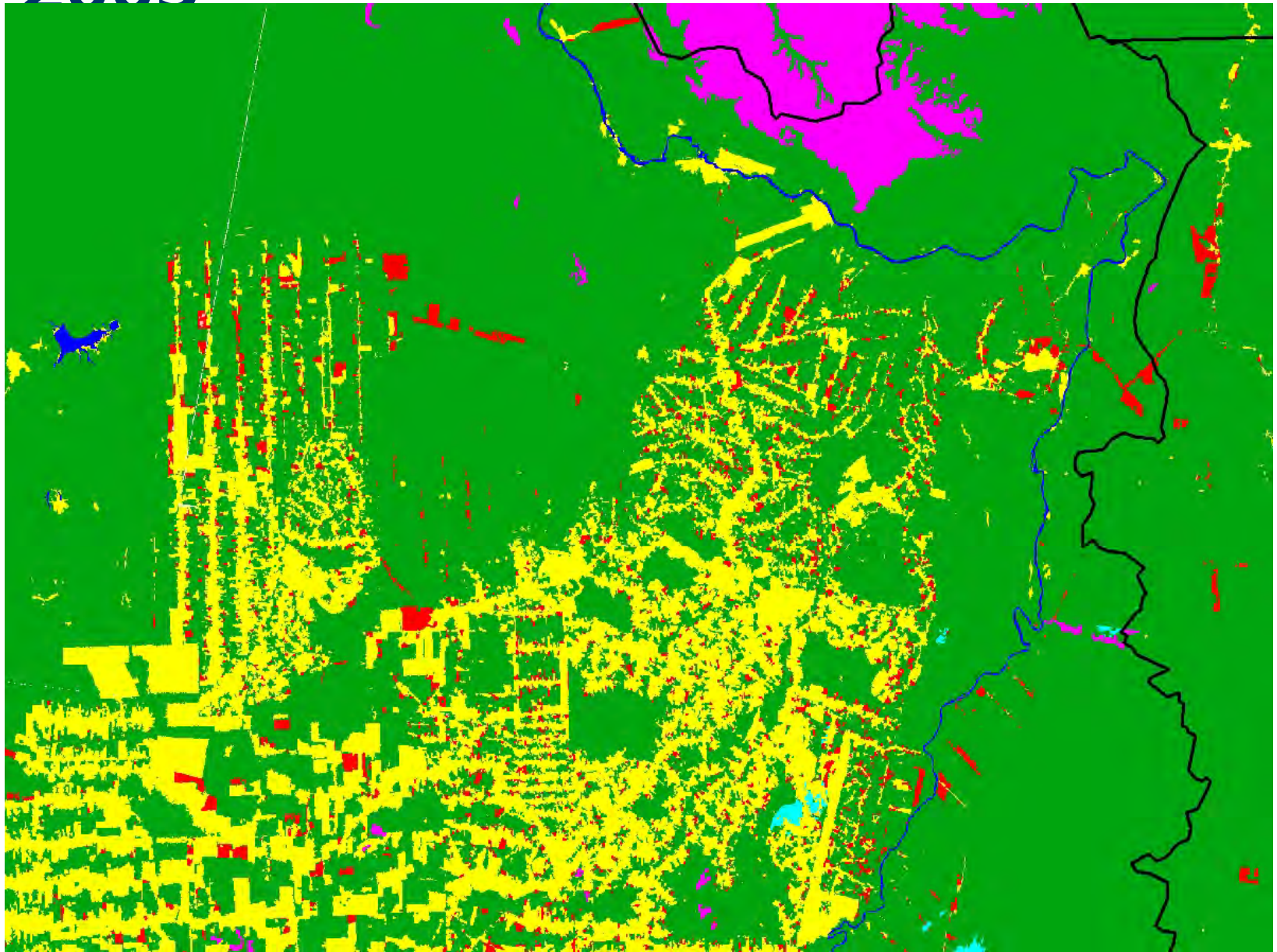
Window... Microsoft... Entrada - M... 2 Firefox... Master Volu... Master Volu...

7:43 PM



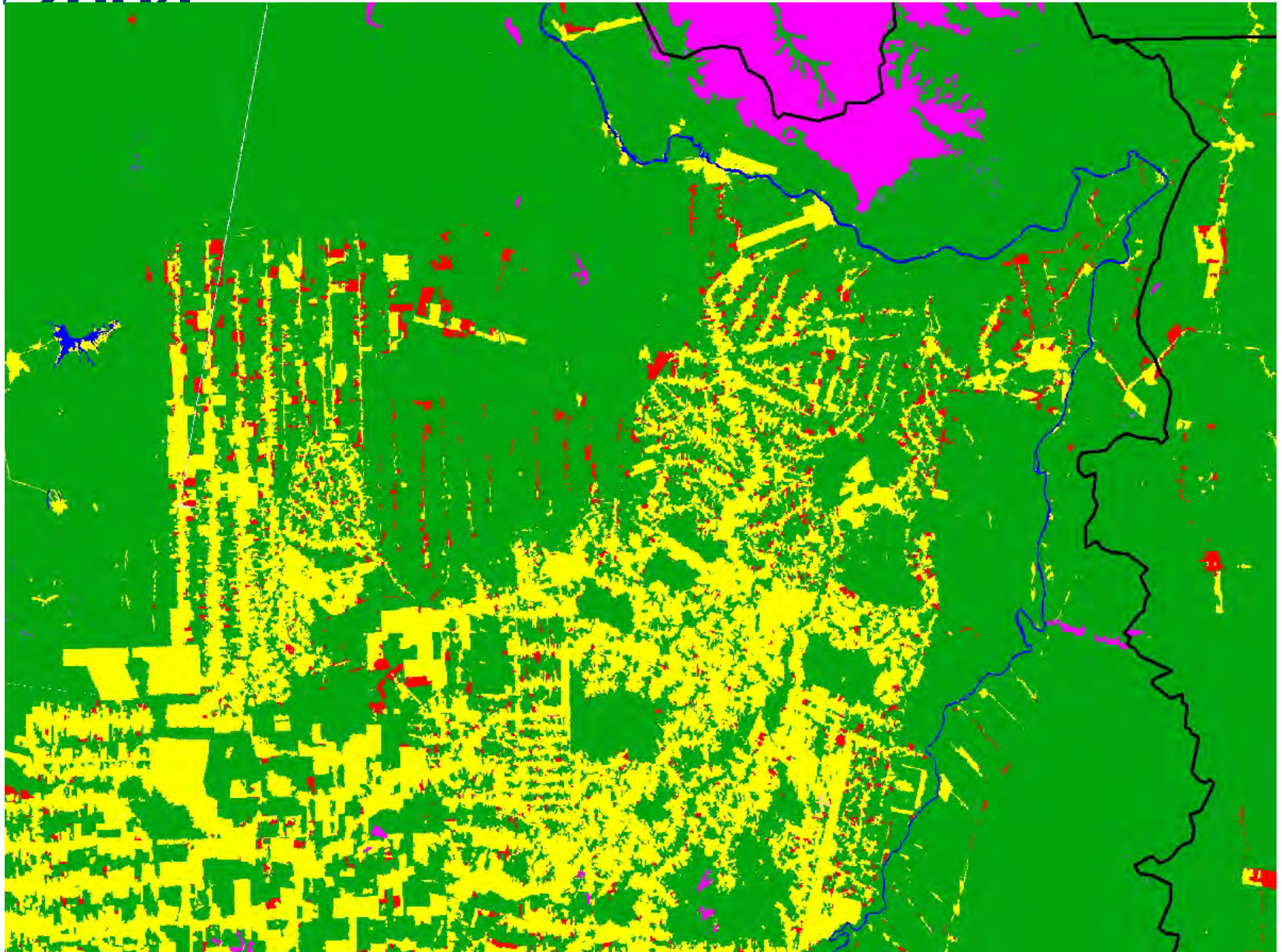


Deforestation in Rondônia (detail) – 2003



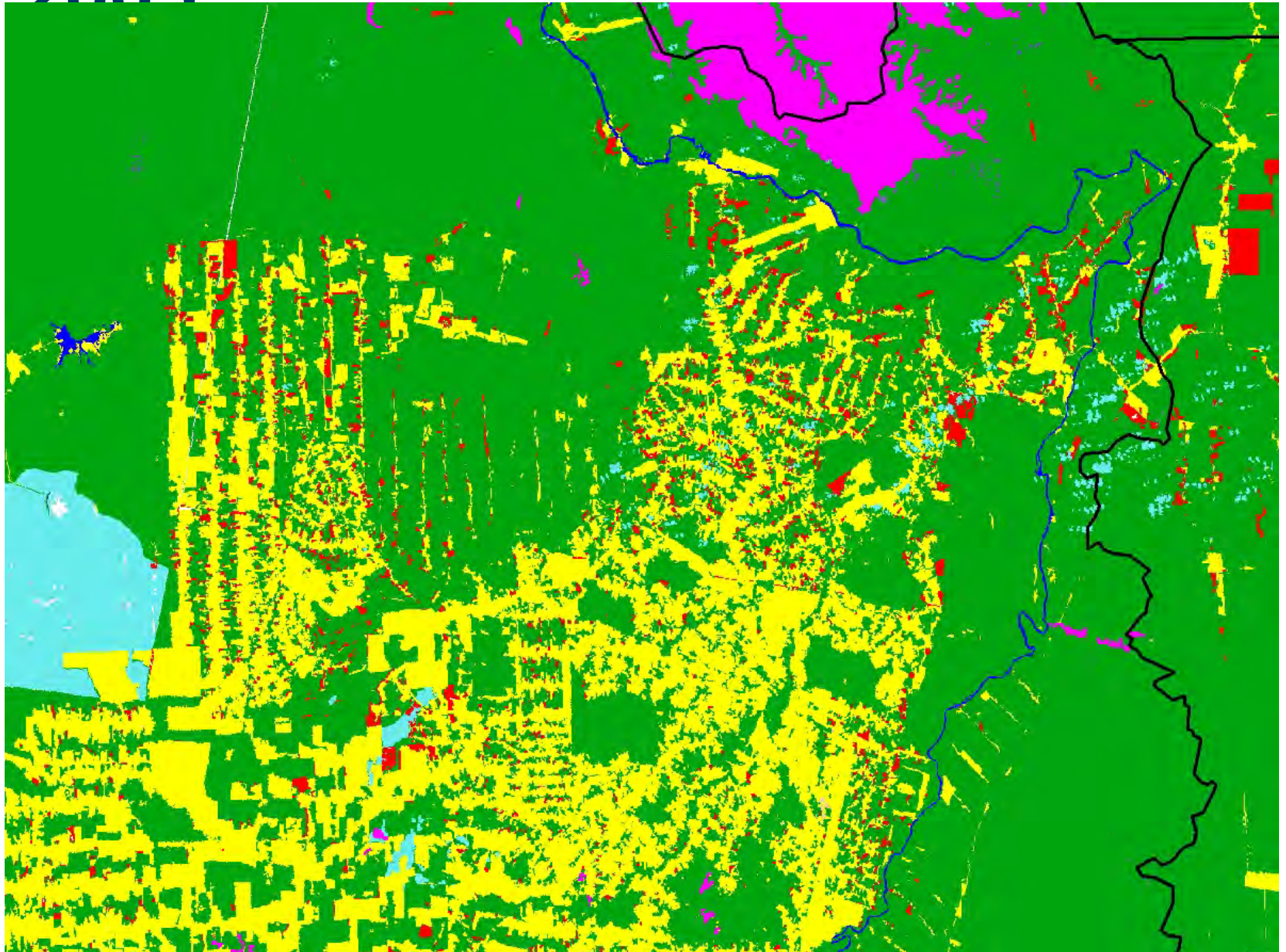


Deforestation in Rondônia (detail) – 2004





Deforestation in Rondônia (detail) – 2005



DETER - Desmatamento nos Municípios e Unidades Conservação - Microsoft Internet Explorer

Arquivo Editar Exibir Favoritos Ferramentas Ajuda

Endereço <http://www.obt.inpe.br/deter/bduc.html> Ir

Links Proarco-Ibama BD-Queimadas Queimadas-Cptec phpMyAdmin Geo Calc Prodes Digital BD UCs Banco Itaú BD Municípios Google

Google Search Web Site popups allowed Options

Coordenação-Geral de Observação da Terra - ORT

DETER - Desmatamento nos Municípios e Unid. Conservação

Parâmetros Básicos

Data Inicial (aaaa-mm-dd) 2004-05-01
Data Final (aaaa-mm-dd) 2004-07-07
Estado TODOS
Base Operativa/Ibama TODAS
Satélite MODIS 01
Faixa de Área Maior que 25 ha
Agrupar por Unidade Conservação
Tipo UC Federal + Estadual
Nome UC Federal Todas
Nome UC Estadual Todas
Executa

Gráficos
Tipo Municípios
Histograma

Municípios Críticos
Faixa Criticidade Crítica
Mostra

2) [S090502062415220040608120000](#) (clique p/ ver)
Tipo UC: **Federal** Nome: **Buffer Interno F.N. Jamari**
Município/Estado: **Cujubim/RO**

Nr	Lat	Long	LatGMS	LongGMS	Data	Satelite	Area (Km2/Ha)
1	-9.0839	-62.6981	S 9 5 2.07	O 62 41 52.99	2004-06-08	MODIS-01	1.0472 / 104.7
2	-9.2673	-62.6969	S 9 16 2.15	O 62 41 49.01	2004-06-08	MODIS-01	2.0560 / 205.6
Area Total							3.1032 / 310.3

[Gera arquivo .txt / Save .txt file / Graba archivo .txt](#)

3) [S094220055533520040608120000](#) (clique p/ ver)
Tipo UC: **Estadual** Nome: **Buffer Interno P.E. do Cristalino**
Município/Estado: **Alta Floresta/MT**

Nr	Lat	Long	LatGMS	LongGMS	Data	Satelite	Area (Km2/Ha)
1	-9.7189	-55.4922	S 9 43 7.88	O 55 29 31.99	2004-06-08	MODIS-01	0.6140 / 61.4
2	-9.7056	-55.8931	S 9 42 20.10	O 55 53 35.29	2004-06-08	MODIS-01	1.1241 / 112.4
Area Total							1.7381 / 173.8

[Gera arquivo .txt / Save .txt file / Graba archivo .txt](#)

4) [S120653063004020040608120000](#) (clique p/ ver)
Tipo UC: **Federal** Nome: **Buffer externo R.B. do Guaporé**
Município/Estado: **São Miguel do Guaporé/RO**

Nr	Lat	Long	LatGMS	LongGMS	Data	Satelite	Area (Km2/Ha)
1	-12.1149	-63.0111	S 12 6 53.77	O 63 0 40.11	2004-06-08	MODIS-01	1.8194 / 181.9
2	-12.3122	-63.5224	S 12 18 43.86	O 63 31 20.67	2004-06-08	MODIS-01	3.6604 / 366.0
Area Total							5.4798 / 548.0

[Gera arquivo .txt / Save .txt file / Graba archivo .txt](#)

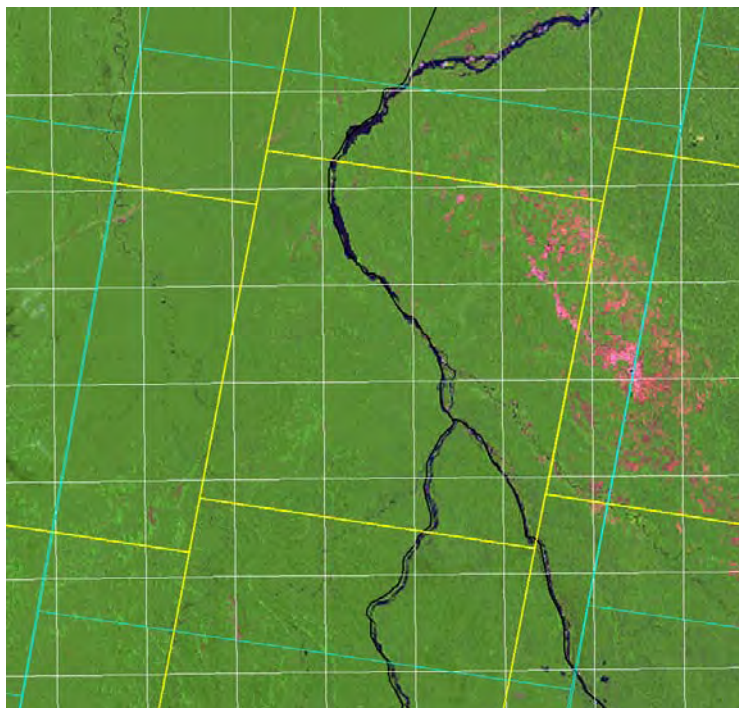
5) [S091626049500920040521120000](#) (clique p/ ver)
Tipo UC: **Estadual** Nome: **A.P.A. Ilha do Bananal/Cantão**
Município/Estado: **Caseara/TO**

Nr	Lat	Long	LatGMS	LongGMS	Data	Satelite	Area (Km2/Ha)
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Report by automatic e-mail of
New deforestation detected in
Conservation Units and
Municipalities

SQL TerraLib php

Concluído Internet

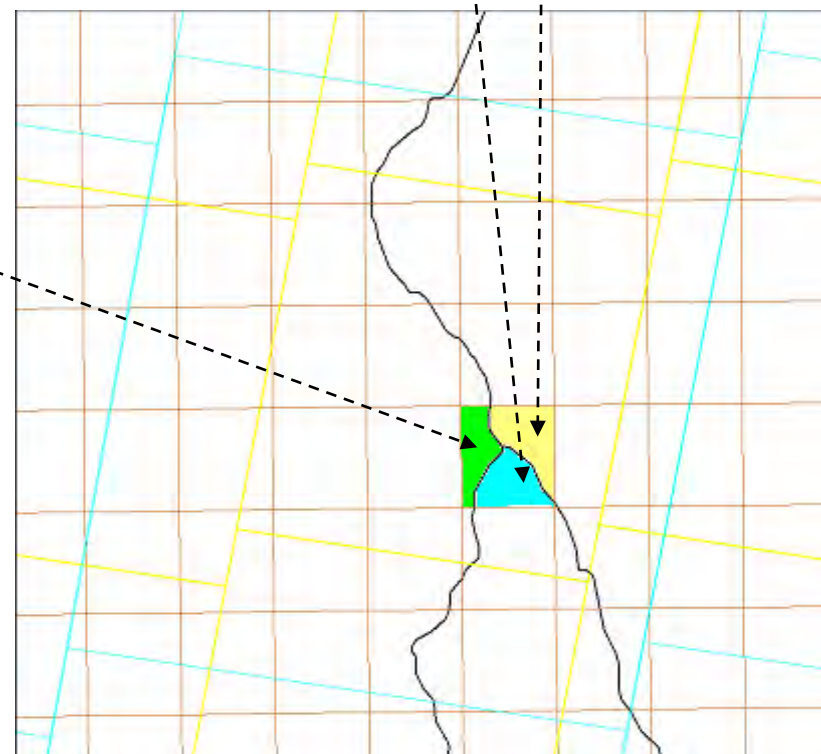


Multidata approach

LANDSAT

CCD/CBERS

DMC



- LANDSAT
- CBERS
- SISPRODES
- State boundaries



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Monitoring the State of the Forest: DEGRAD e DETEX

cell

8

562_27092007_2

267_27082007_1

467_310706

862_311006_v2

ETIVO

STAMENTO

0_2008

a

RTÉ

_AR

R

008

RR163

OR_2007_ENTREGA_M

006x2007

07_inter_FP

663_19082008

0808_SLxVg_90_50_M

0808_SLxVg_90_50_M_1

0808_SLxVg_90_50_M

0808_SLxVg_90_50_M_1

0808_SLxVg_90_50_M_2

668_03082008_2

668_03082008_4

868_12082006



cell

08

562_27092007_2

267_27082007_1

467_310706

862_311006_v2

ETIVO

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OR_2007_ENTREGA_M

006x2007

07_inter_FP

663_19082008

0808_SLxVg_90_50_M

08_SLxVg_90_50_M_1

0808_SLxVg_90_50_M

08_SLxVg_90_50_M_1

08_SLxVg_90_50_M_2

668_03082008_2

668_03082008_4

868_12082006



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562_27092007_2

267_27082007_1

467_310706

862_311006_v2

ETIVO

STAMENTO

0_2008

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RR163

OR_2007_ENTREGA_M

006x2007

07_inter_FP

663_19082008

0808_SLxVg_90_50_M

08_SLxVg_90_50_M_1

0808_SLxVg_90_50_M

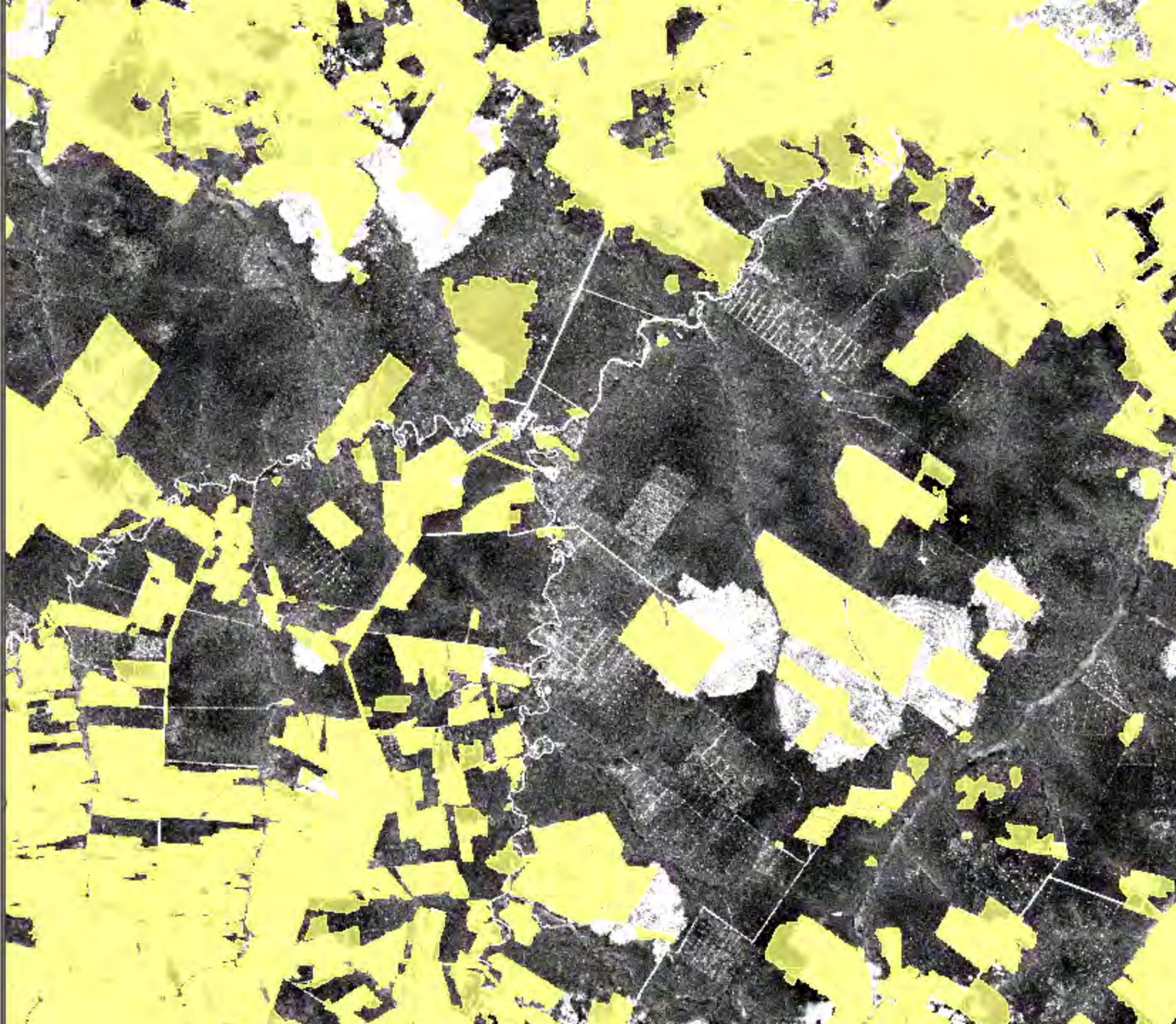
08_SLxVg_90_50_M_1

08_SLxVg_90_50_M_2

668_03082008_2

668_03082008_4

868_12082006



cell

08

562_27092007_2

267_27082007_1

467_310706

862_311006_v2

ETIVO

STAMENTO

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IR163

OR_2007_ENTREGA_M

006x2007

07_inter_FP

663_19082008

0808_SLxVg_90_50_M

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0808_SLxVg_90_50_M

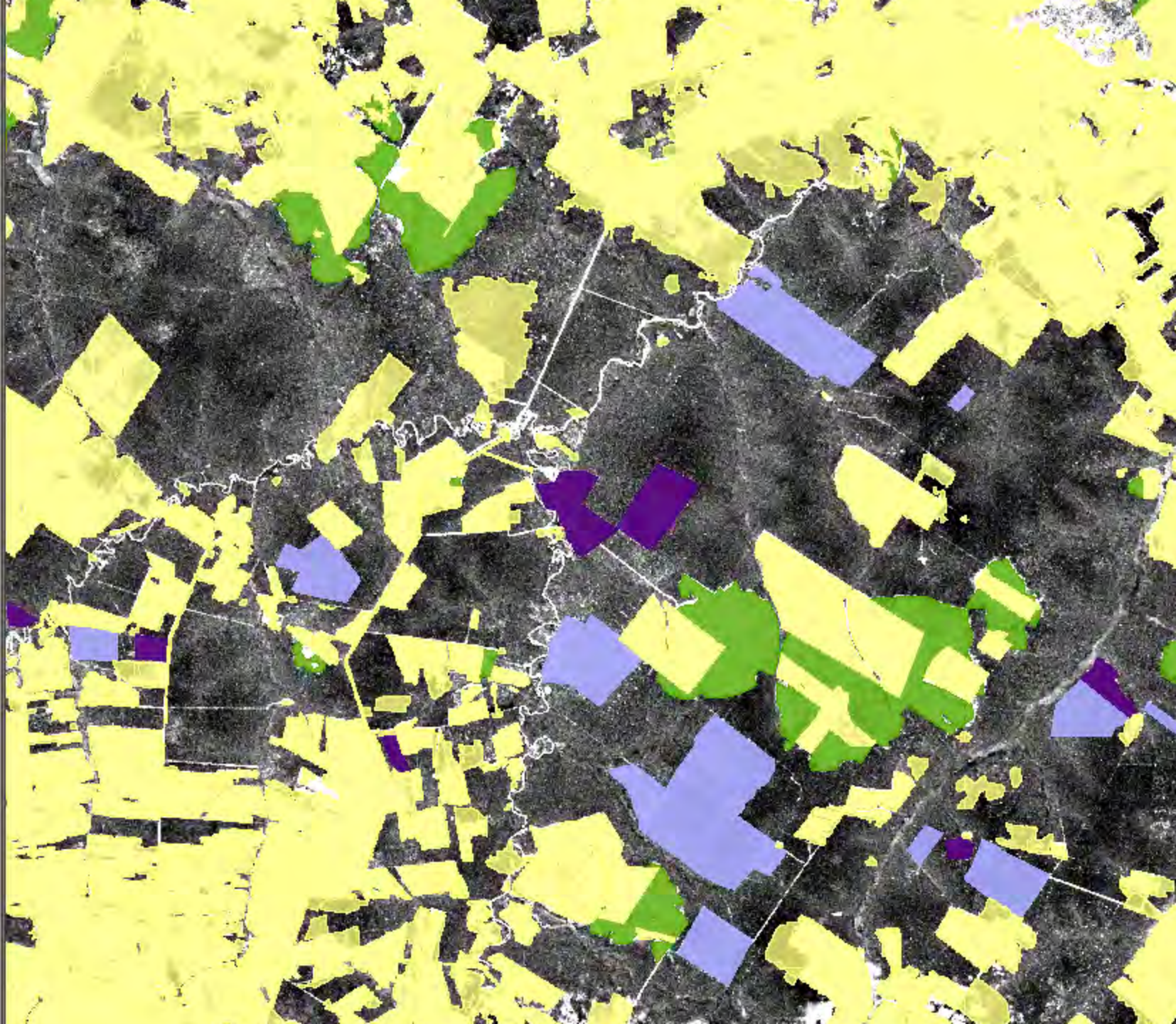
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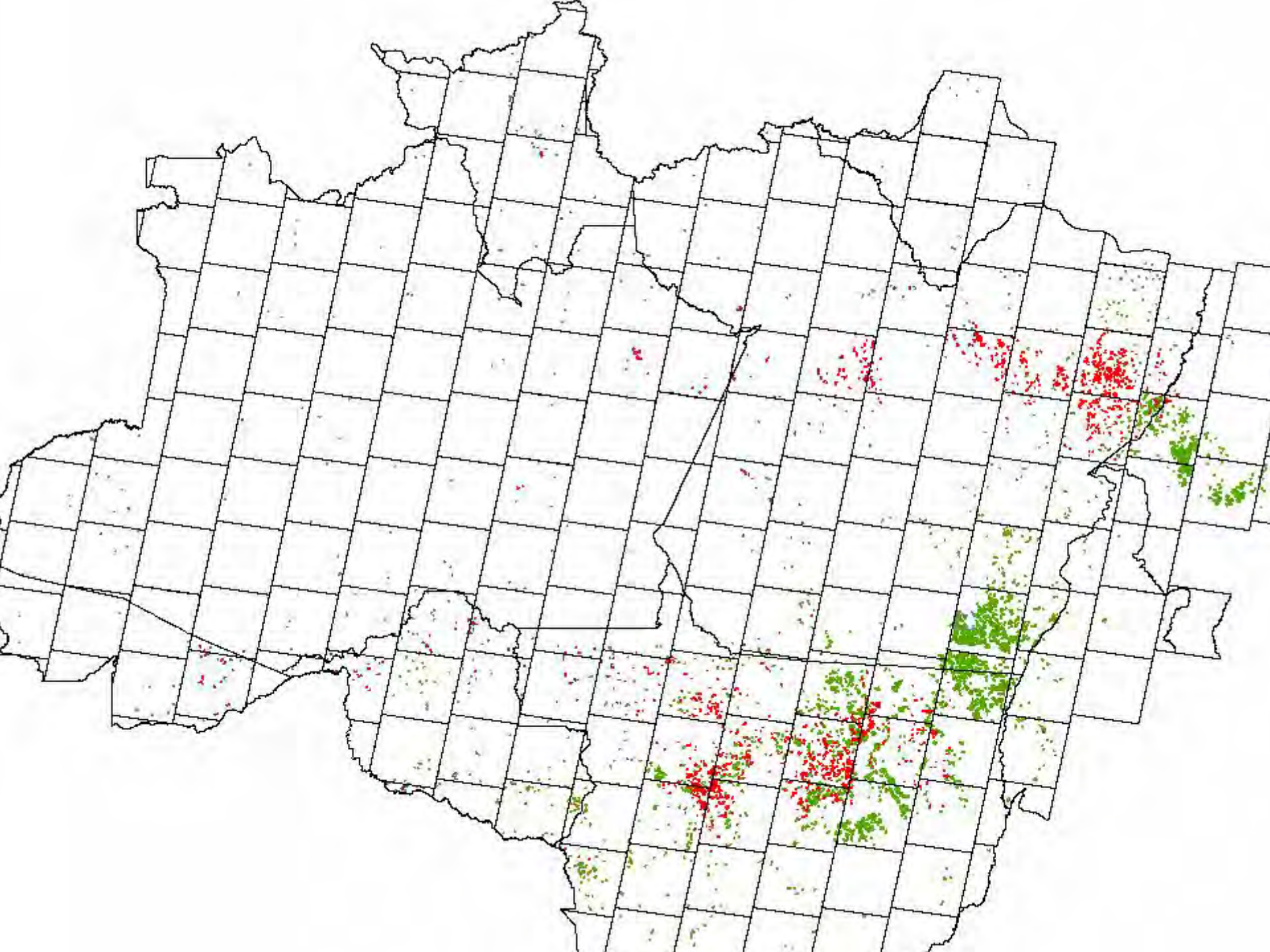
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668_03082008_2

668_03082008_4

868_12082006



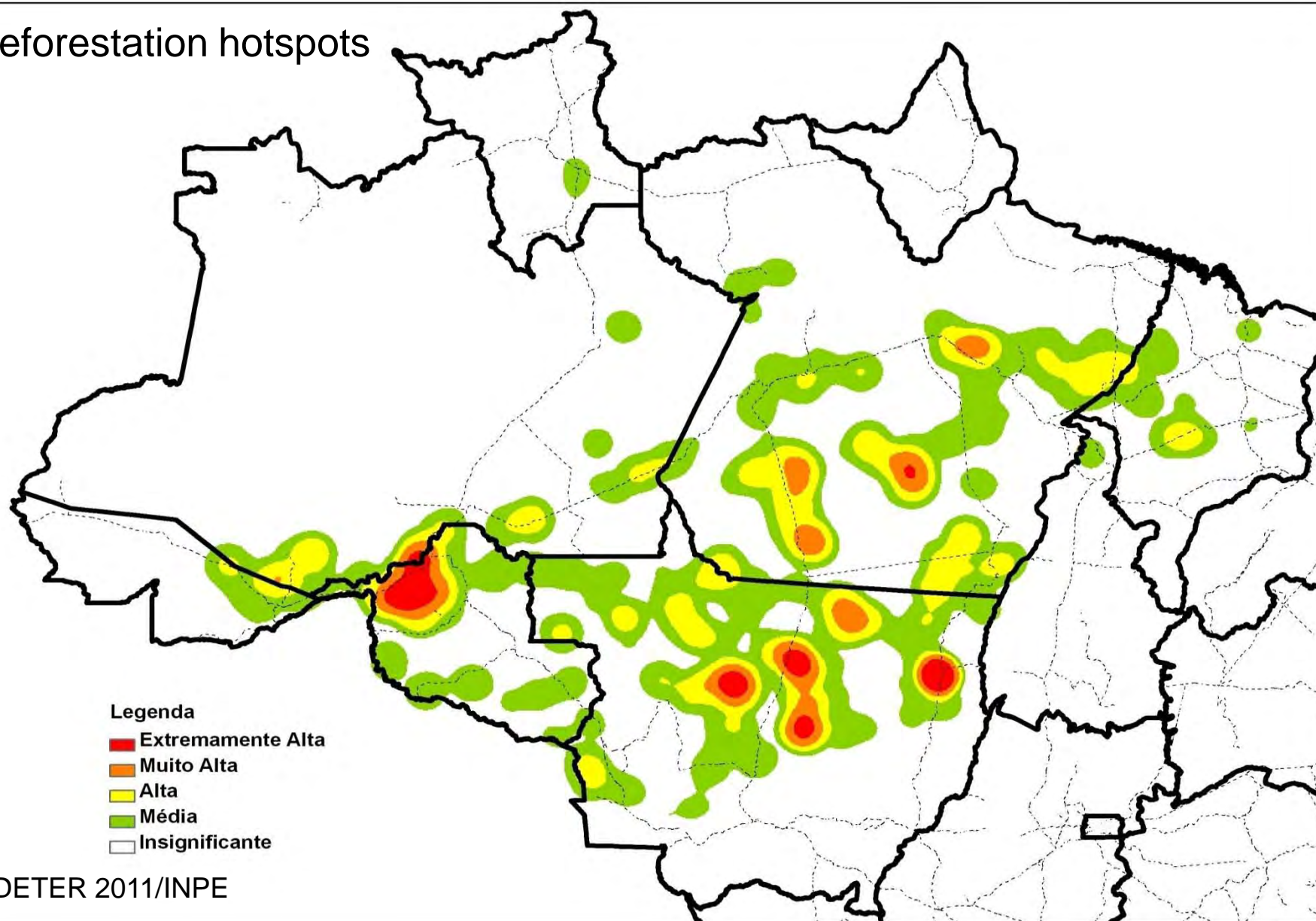




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Near Real Time Monitoring of the Legal Amazonia - DETER

Deforestation hotspots





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Near Real Time Monitoring of the Legal Amazonia - DETER



Carbon maps for Brazilian Amazonia

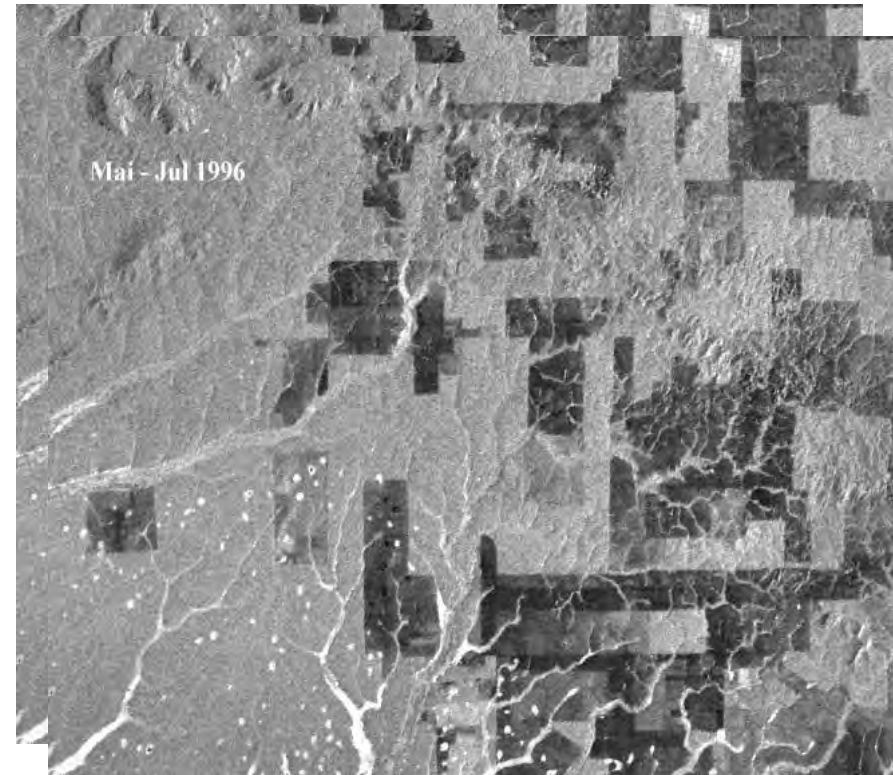
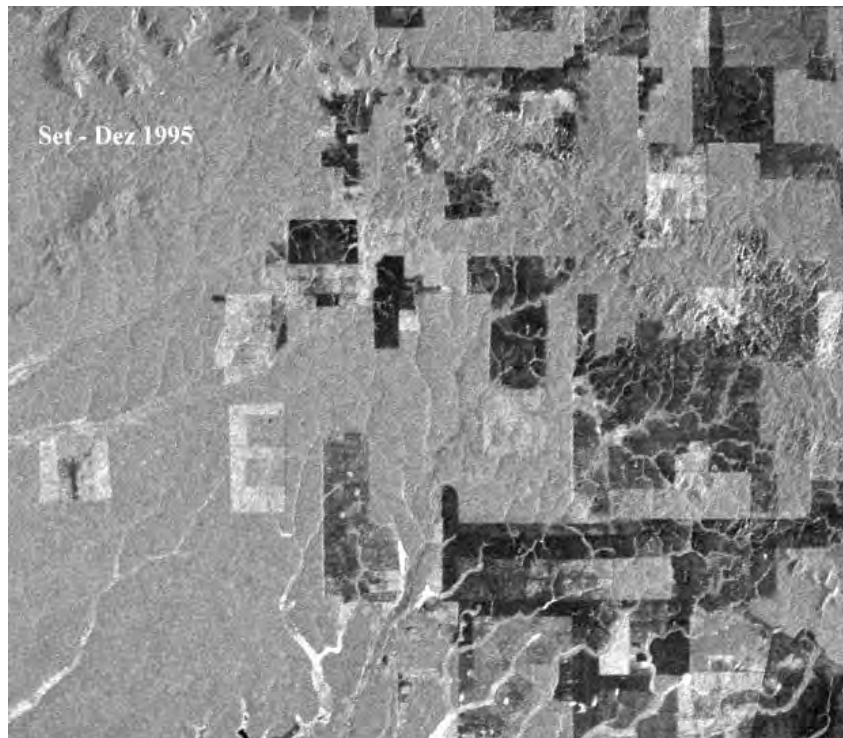
- Largest source of uncertainty regarding carbon emissions from deforestation is the spatial distribution of biomass.
- Differences in emission estimates can be on the order of 20% using our baseline model parameters.
- Estimates based on submodels B1 (Saatch et al., 2007), B3 (MCT, 2010) and B4 (Saatchi et al., 2011a,b) are relatively similar at the regional level, those based on B2 (Nogueira et al., 2008) are significantly higher.
- This difference could be even higher if the same percentage of BGB in relation to AGB in all the submodels.
 - Root to shoot ration is 20% in B2, 28% in B3 and 30% in B1–B4.
- The emission estimate differences would increase to 30% as BGB contribution in B2 would be larger.



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DETER-R : Assimilation of PALSAR data in the Deforestation and Forest Degradation Warning System

Examples of L-band deforestation detection capability from JERS-1 GRFM Mosaics



Examples of L-band deforestation detection capability from ALOS/PALSAR

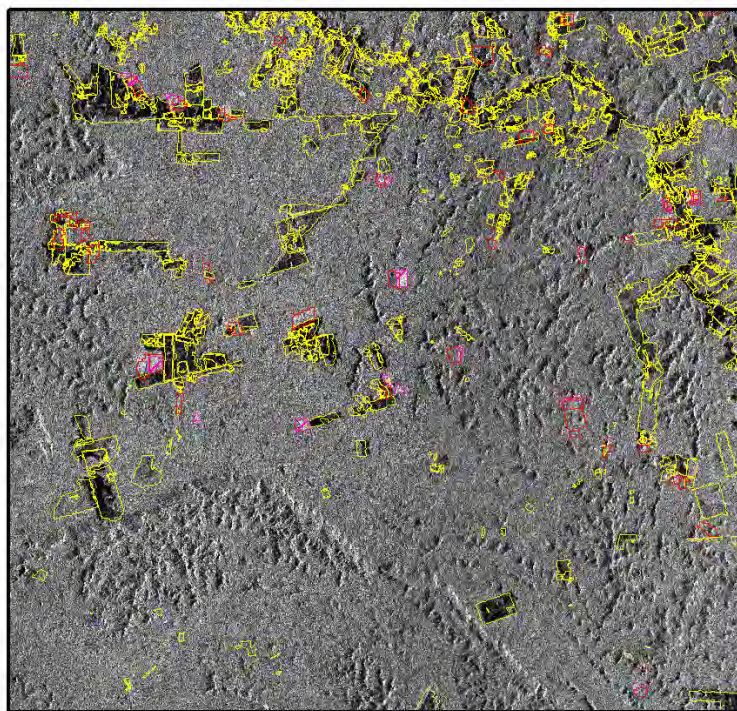


Imagem ALOS de 23/08/2007

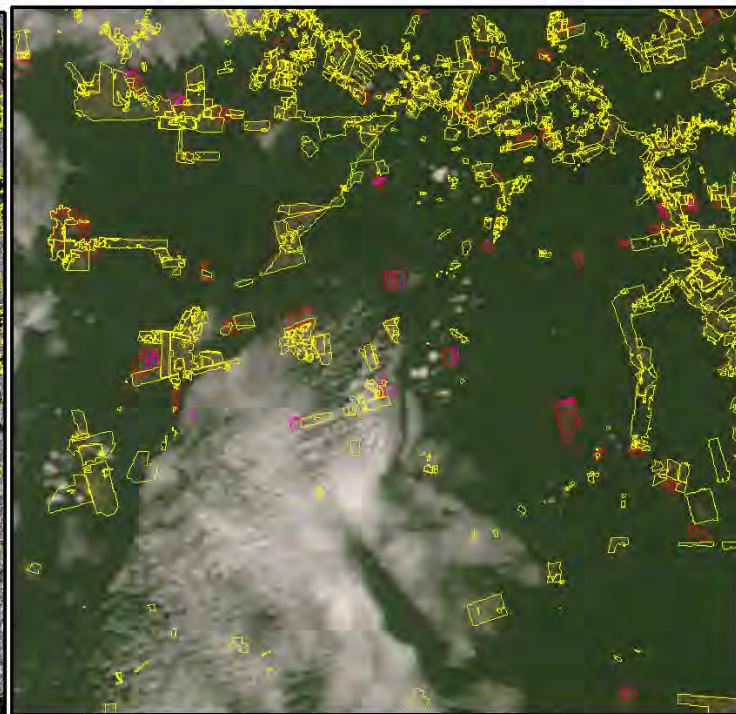
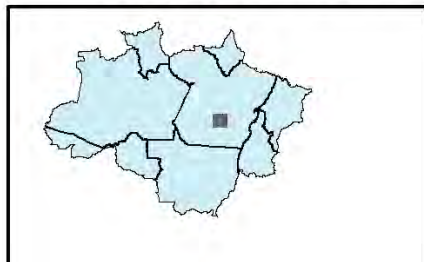





Imagem MODIS de 28/09/2007



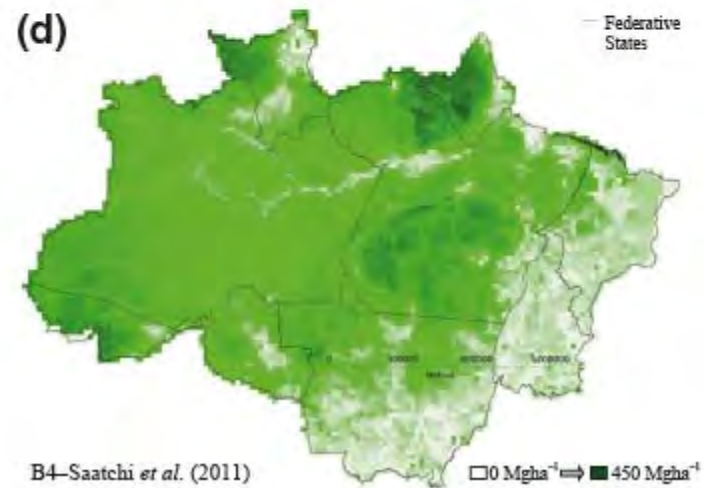
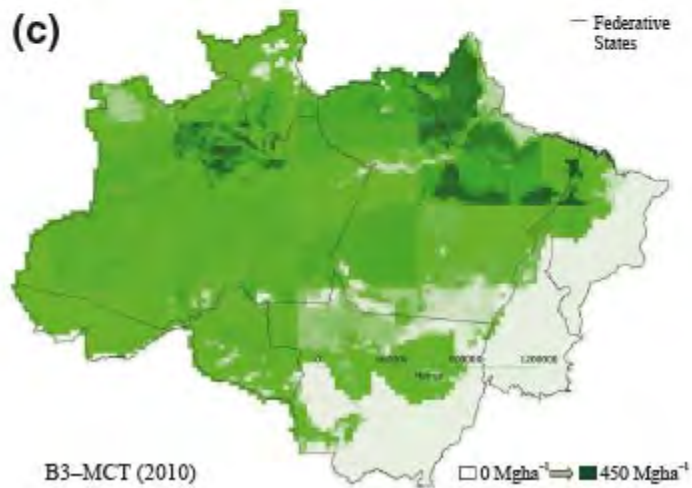
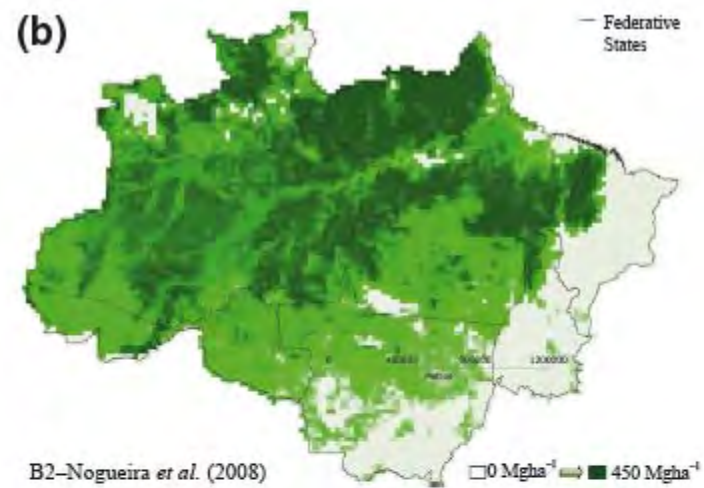
Legenda

-  Detecções com uso do ALOS
-  DETER acumulado 2007
-  PRODES 2000 a 2006



Modeling the spatial and temporal heterogeneity of deforestation-driven carbon emissions: the INPE-EM framework applied to the Brazilian Amazon

Global Change Biology (2012), doi: [10.1111/j.1365-2486.2012.02782.x](https://doi.org/10.1111/j.1365-2486.2012.02782.x)





Carbon maps for Brazilian Amazonia

- Largest source of uncertainty regarding carbon emissions from deforestation is the spatial distribution of biomass.
- Differences in emission estimates can be on the order of 20% using our baseline model parameters.
- Estimates based on submodels B1 (Saatch et al., 2007), B3 (MCT, 2010) and B4 (Saatchi et al., 2011a,b) are relatively similar at the regional level, those based on B2 (Nogueira et al., 2008) are significantly higher.
- This difference could be even higher if the same percentage of BGB in relation to AGB in all the submodels.
 - Root to shoot ration is 20% in B2, 28% in B3 and 30% in B1–B4.
- The emission estimate differences would increase to 30% as BGB contribution in B2 would be larger.



Future – challenges for REDD+

■ Within Brazil

- Expansion of the deforestation and forest degradation systems to include all biomes: national system
- Adapt the present monitoring system to the specificities of other biomes
- Data availability – some biomes require satellite data of finer spatial resolution (less than 5 meters)
- Implement a national forest inventory
- Going beyond fiscalization and law enforcement
- Definition of reference emission level for all biomes (RL for Amazonia used only historical



Future – challenges for REDD+

■ Within Brazil

- When conservation (maintenance of carbon stock) can be considered a mitigation activity and not BAU?
- Estimating carbon stock change beyond IPCC tier 1 method and conservativeness for all biomes.
- How to treat natural disturbances?

The background of the slide is an aerial photograph of a vast, dense tropical forest, likely the Amazon. The canopy is a mosaic of various shades of green, with some lighter patches indicating different tree species or forest structure. The perspective is from a high altitude, looking down on the forest floor.

Thank you