The Amazon Deforestation Monitoring System:
A large environmental database developed
on TerraLib and PostgreSQL

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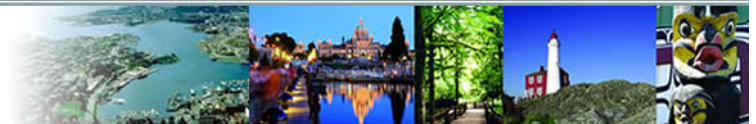
Foundation for Space Science, Technology and Applications

- Non profit private foundation
- Engaged on projects of spatial applied research and spatial technology transfer.
- Founded in 1982 (25 years)
- Technical agreements with Brazilian Research Partners

National Institute for Space Research

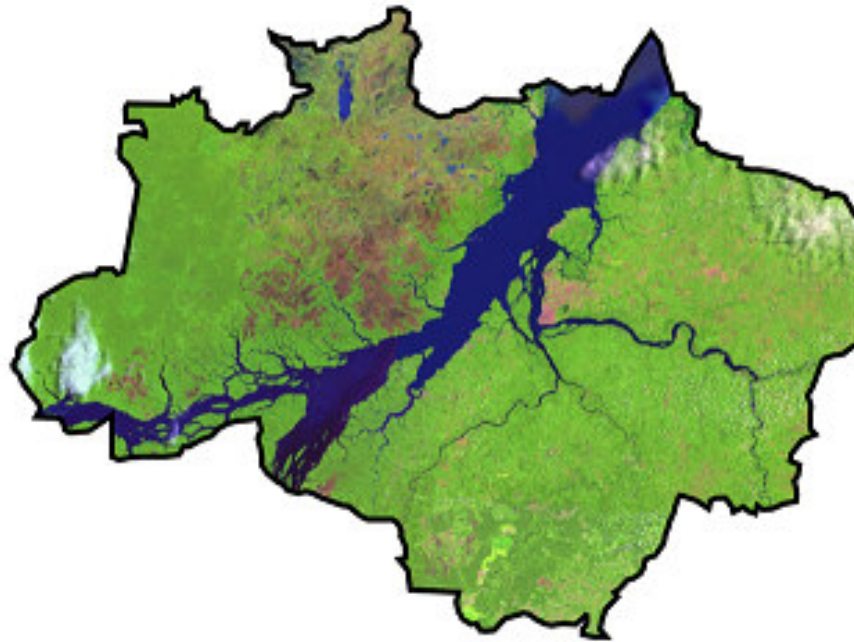**Aerospatial Technical Center
Brazilian Air Force**

Brazilian Technology Institute Science

Mineral Technology Center

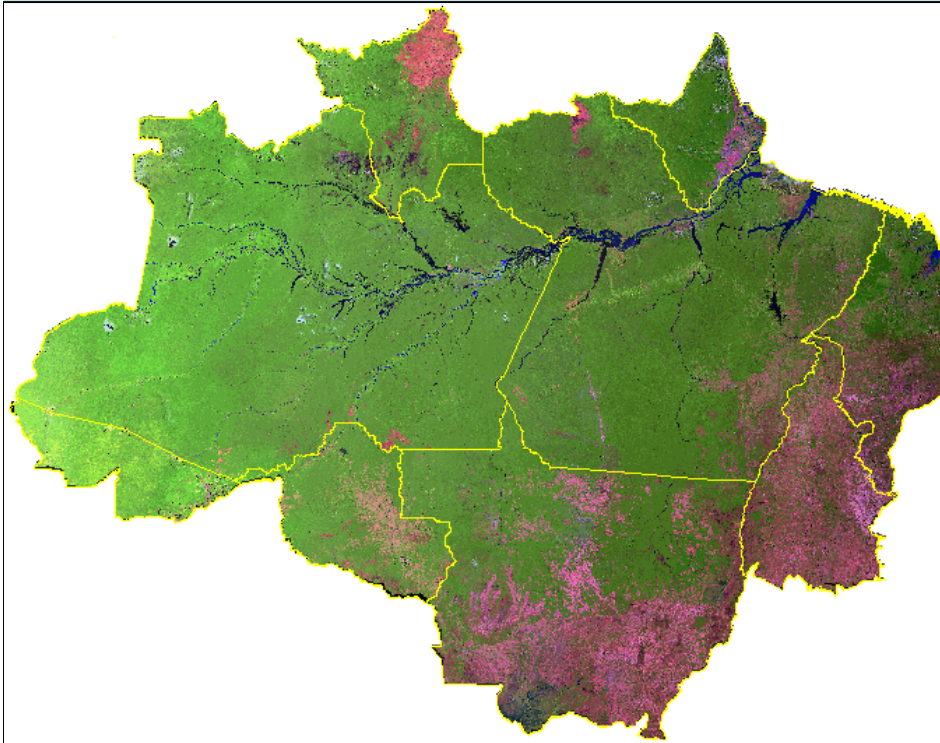The Amazon rainforest monitoring system of the PRODES project.

- To produce deforestation maps of the Brazilian Amazon.

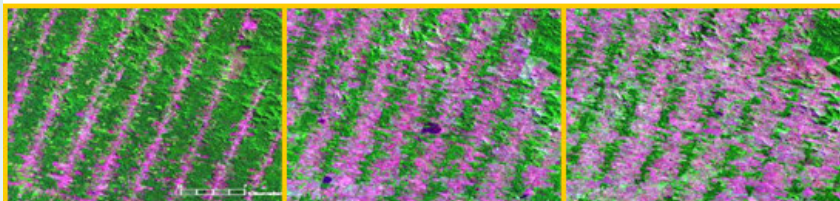- To calculate the annual deforestation rate

Background

- Brazil uses remote sensing satellite data to monitor deforestation in the Brazilian Amazon biome, which covers an area of 4,7 million square kilometers.

- Every year a deforestation map and a yearly deforestation rate, are produced and disseminated through the Internet.

- The monitoring requires that a complete coverage of satellite images, with 20 to 30 meters resolution, to be acquired, automatically processed and analyzed by technicians.
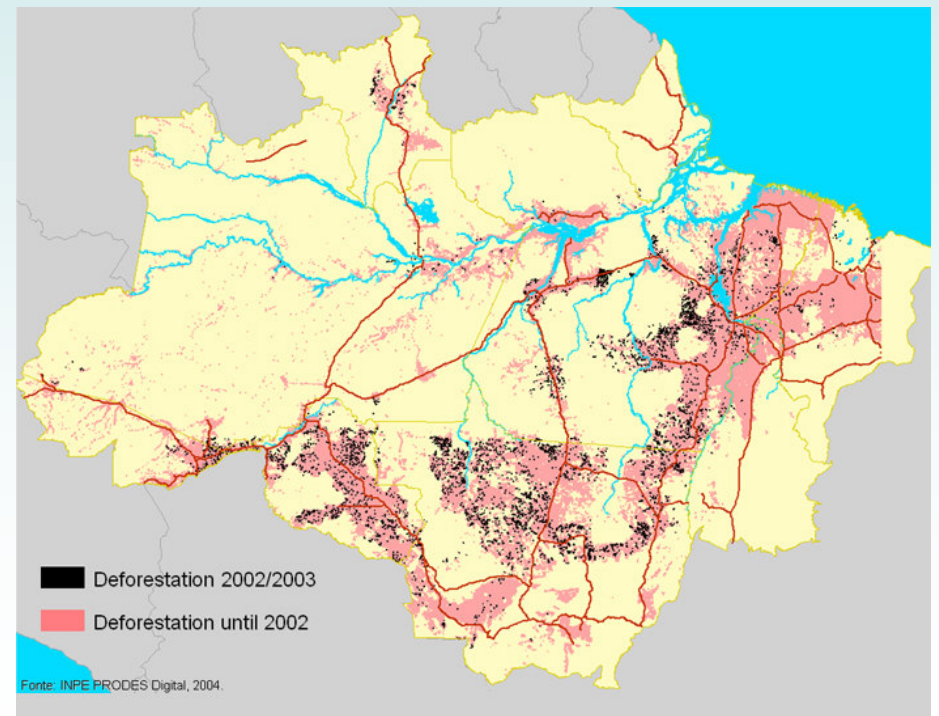
Background
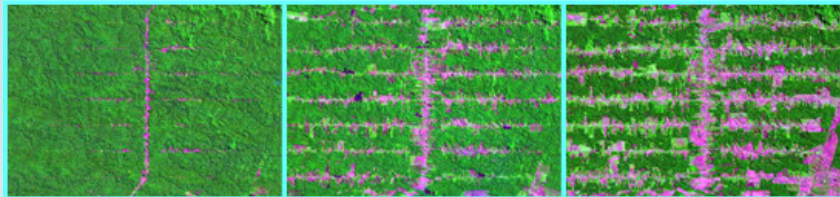
Increasing Deforestation in Amazon

1985   1995   2000

Amazon deforestation in 2003 mapped by PRODES

Deforestation 2002/2003

Deforestation until 2002

Fonte: INPE PRODES Digital, 2004.

- PRODES was initiated at the end of the 80's using analogical interpretation process.

- In the following years deforestation mapping evolved to a fully digital procedure using SPRING. Deforestation mapping demanded 229 independent databases, each one covering one LANDSAT 5 satellite image, creating an environment of complex management.

- The complexity would increase with the use of images from other satellites (CBERS, LANDSAT, DMC), which are needed to guarantee data availability under a satellite operational breakdown.

- **TerraAmazon** was developed to simplify deforestation mapping in this scenario with the advantage of delivering faster results.

Technologies

TerraLib implements methods for image and vector data processing and analysis.

TerraPHP extends PHP to access TerraLib for web applications.

**SPRING implements a variety algorithms for images and vector data processing.**

- Multiplatform LINUX or Windows machines.

- Developed using C++ and the graphical widget toolkit QT.

- Database server running on PostgreSQL version 8.2, on a LINUX Server.

- Developed based on TerraLib open source technology (www.terralib.org).

- Web site running on TerraLib PHP extension and TerraLib OGC WMS server.

- Repository of image processing algorithms SPRING

  www.dpi.inpe.br/spring

- **TerraAmazon** manages all operations using a unique corporate database in a distributed and concurrent environment.

- Cells were created by partitioning the project extents using a 0.25 degrees grid.

- Each interpreter can lock one or more cells to process using a long transactions schema.

- Image processing tools are used to automatically extract deforestation polygons and include: TIFF format image import, georeferencing using control points, enhancement and color composition, mixture model, segmentation, and classification.
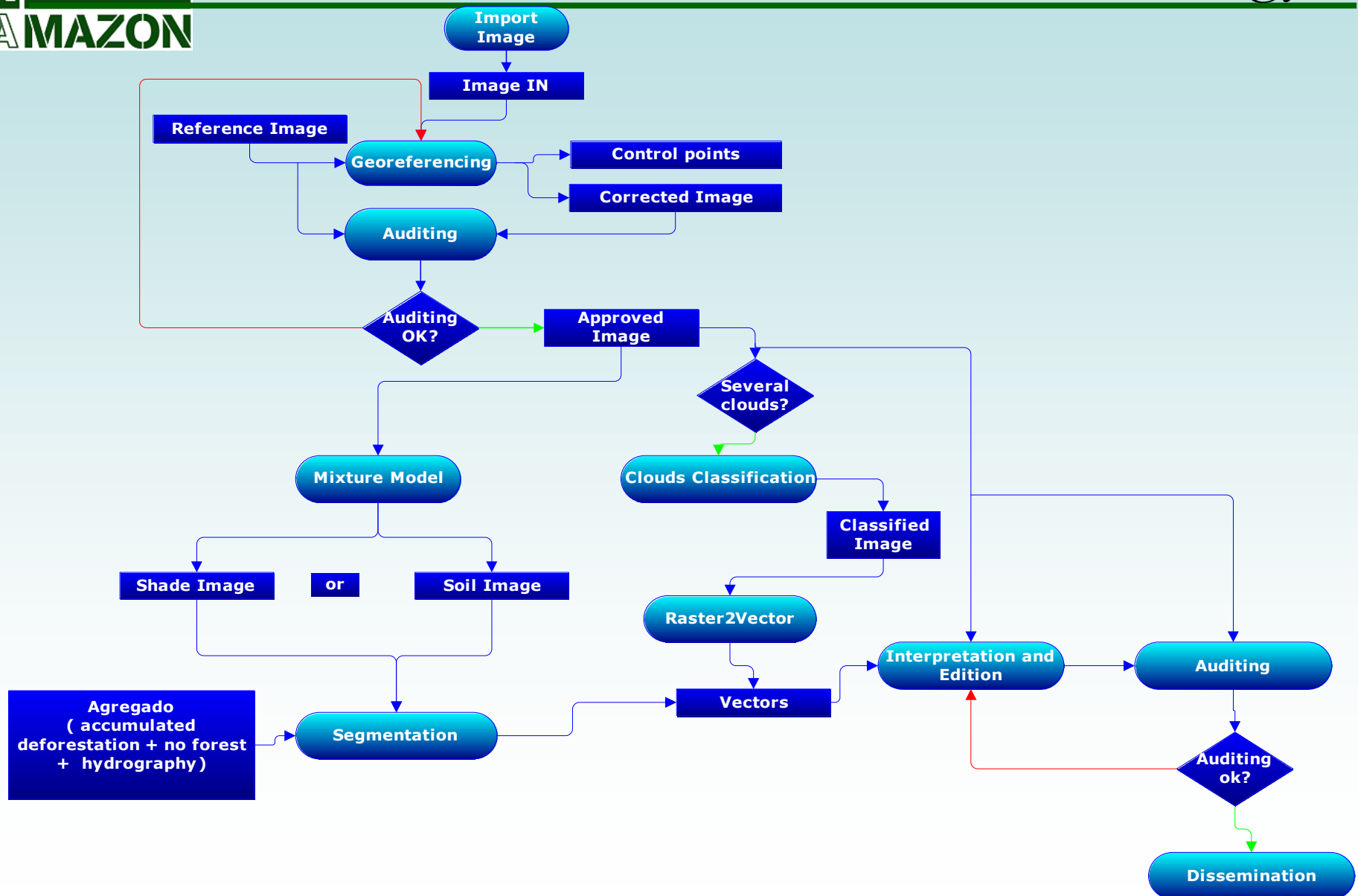
Methodology
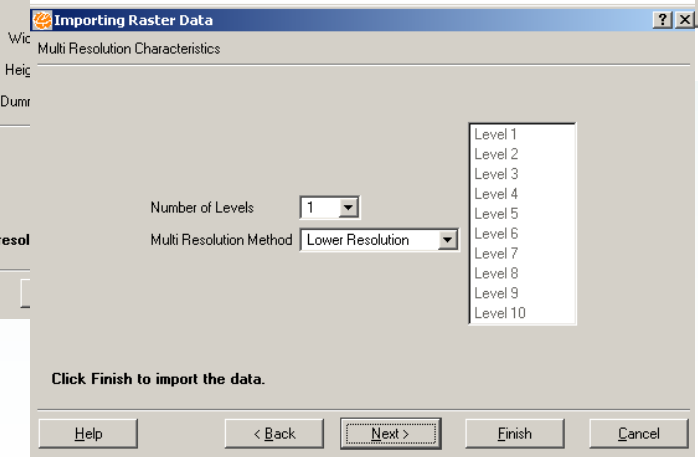
Methodology

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

GeoTIFF

JPEG
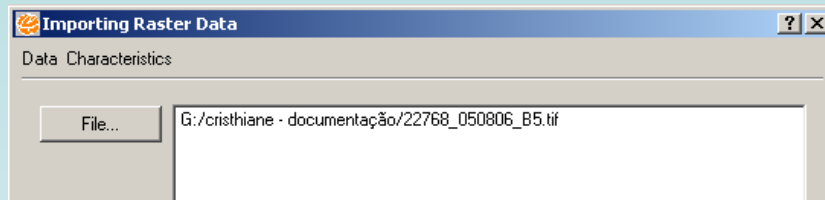
RAW

SPR GRID

ESRI ASCII GRID

Methodology

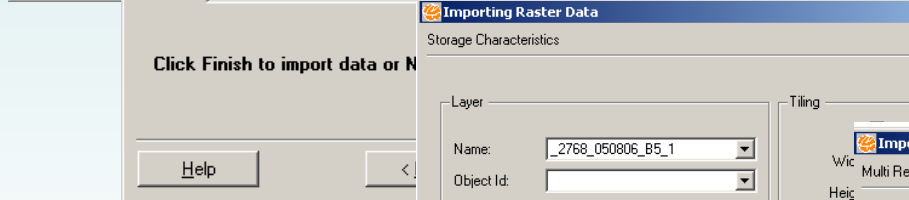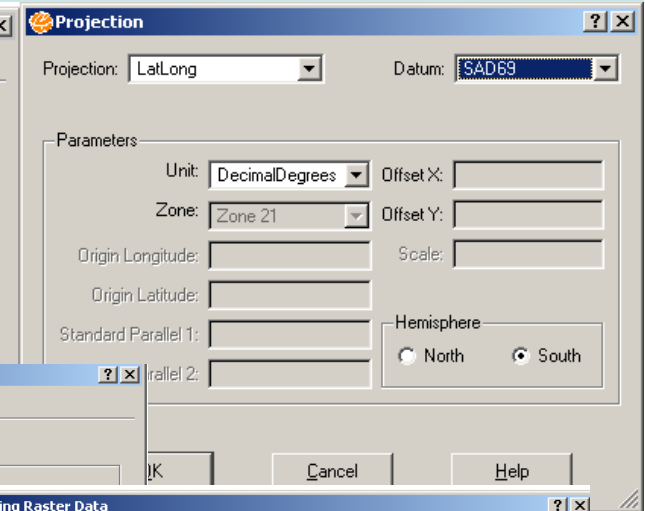Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

- Interpolators:
  - Near Neighborhood
  - Bilinear
  - Bicubic

- Interactive interfaces

- Equalization functions
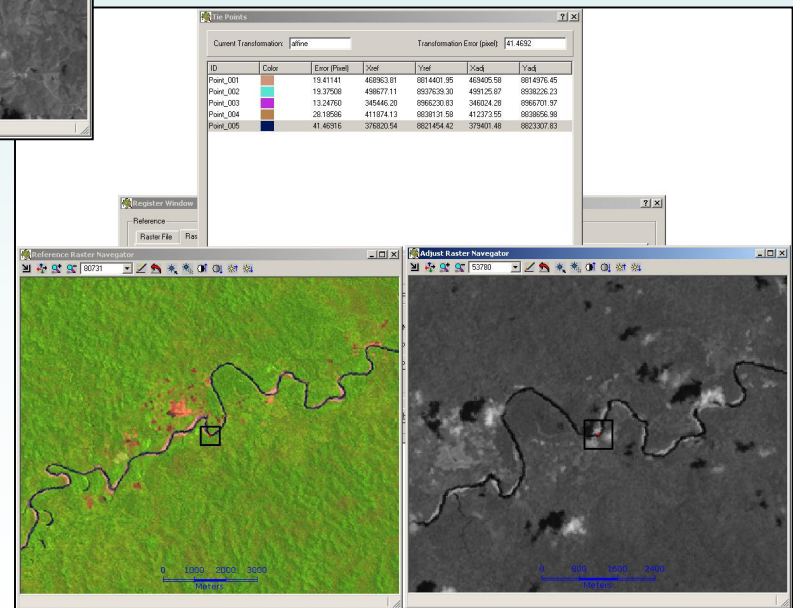
Methodology

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Dissemination

Original Image

Soil Image

Vegetation Image

Shade Image

TERR AMAZON

- Import Image
- Georeferencing
- Mixture Model
- **Segmentation**
- Classification
- Interpretation and Edition
- Auditing
- Dissemination

Input Soil Image

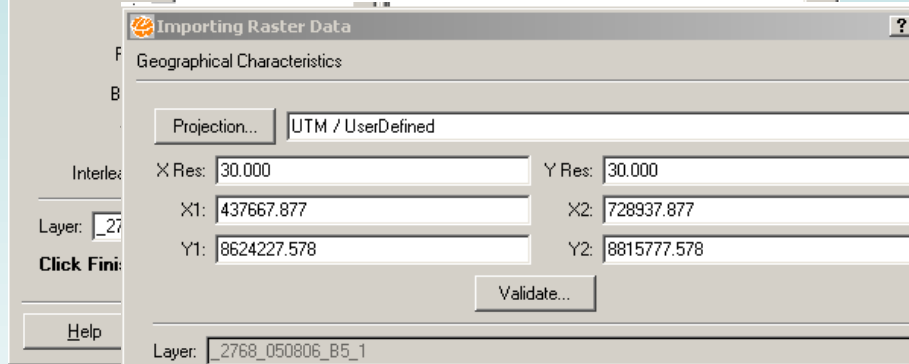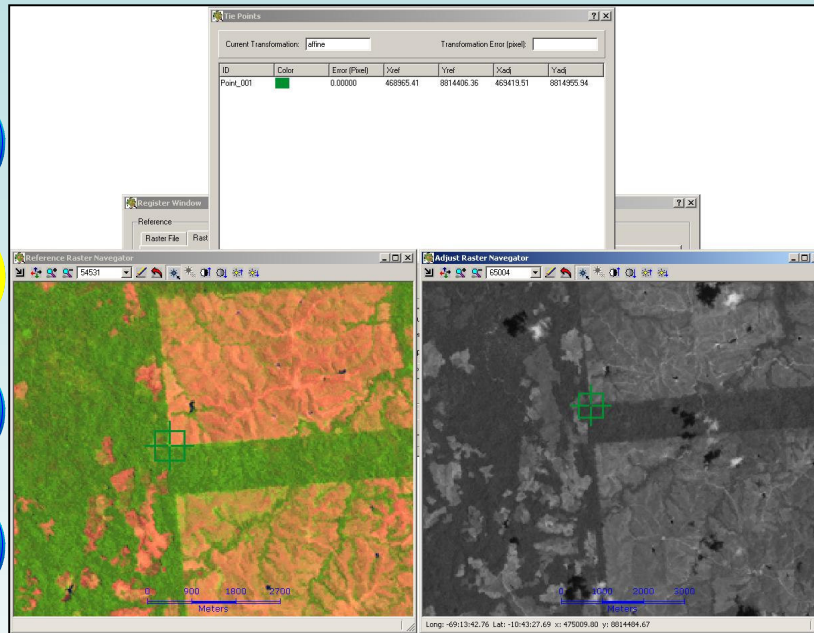Output Vectors

Methodology

- Import Image
- Georeferencing
- Mixture Model
- Segmentation
- Classification
- Interpretation and Edition
- Auditing
- Dissemination

Input Image

Input Image and Output Clouds

K-means classification

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

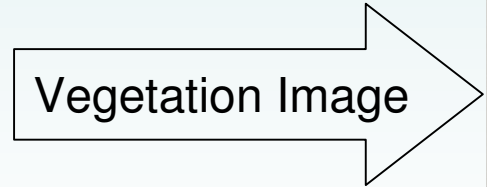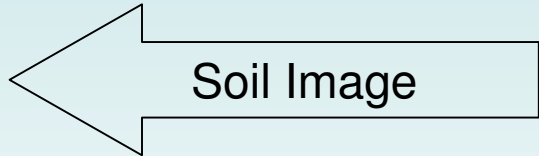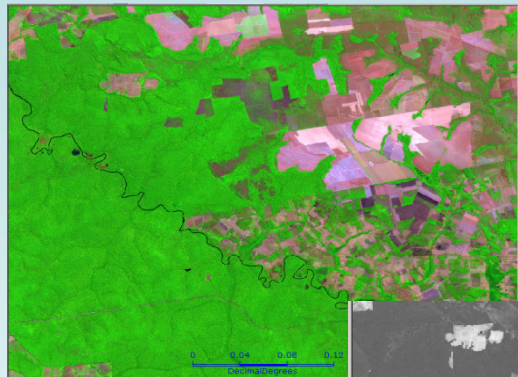CLIP CLOUDS BY CELL

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

Starting edition:

- Defining the scene (satellite,path,row and date);
- Creating a Task;

Methodology

Interpreter has to "check-in" cells to work.

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing
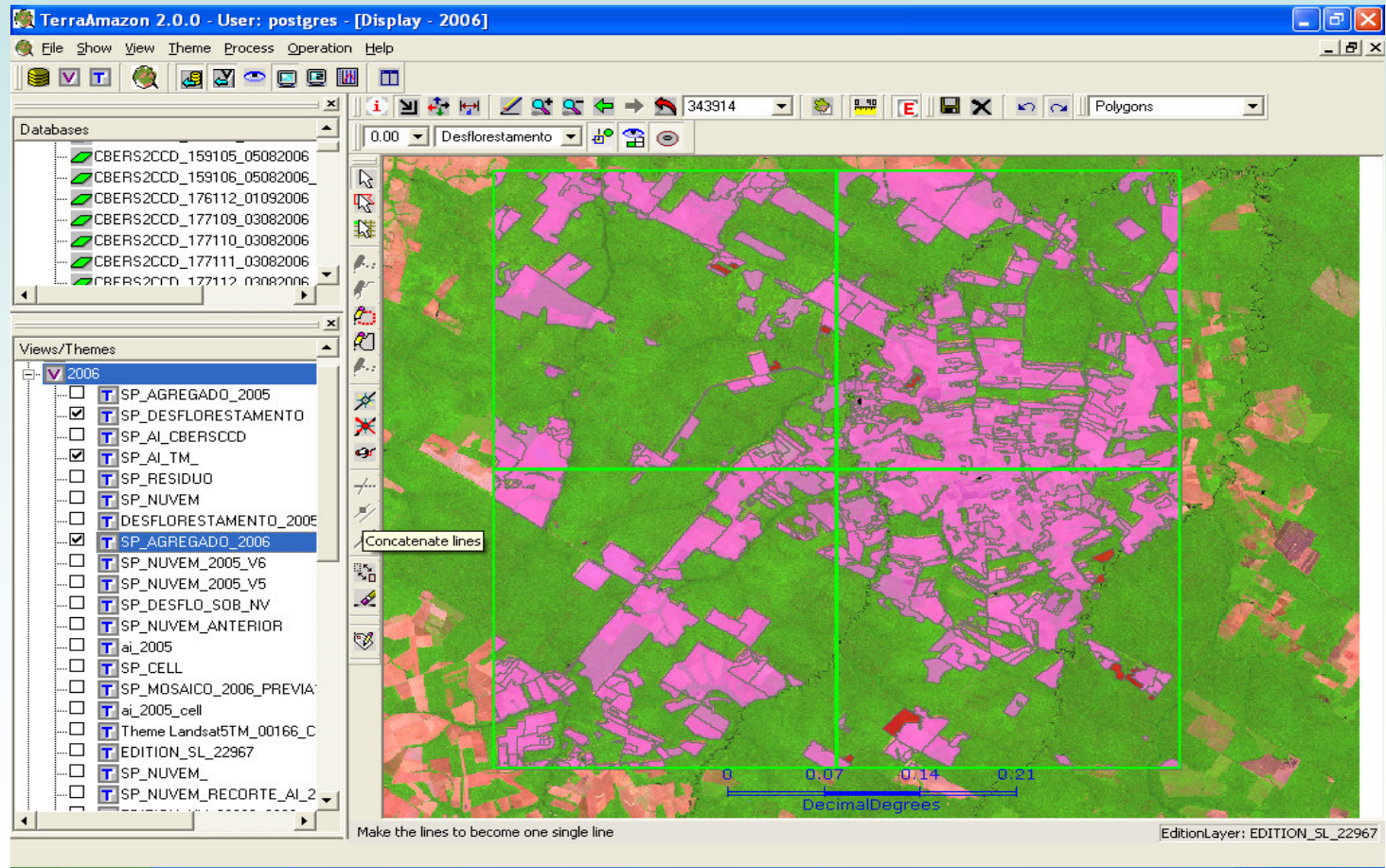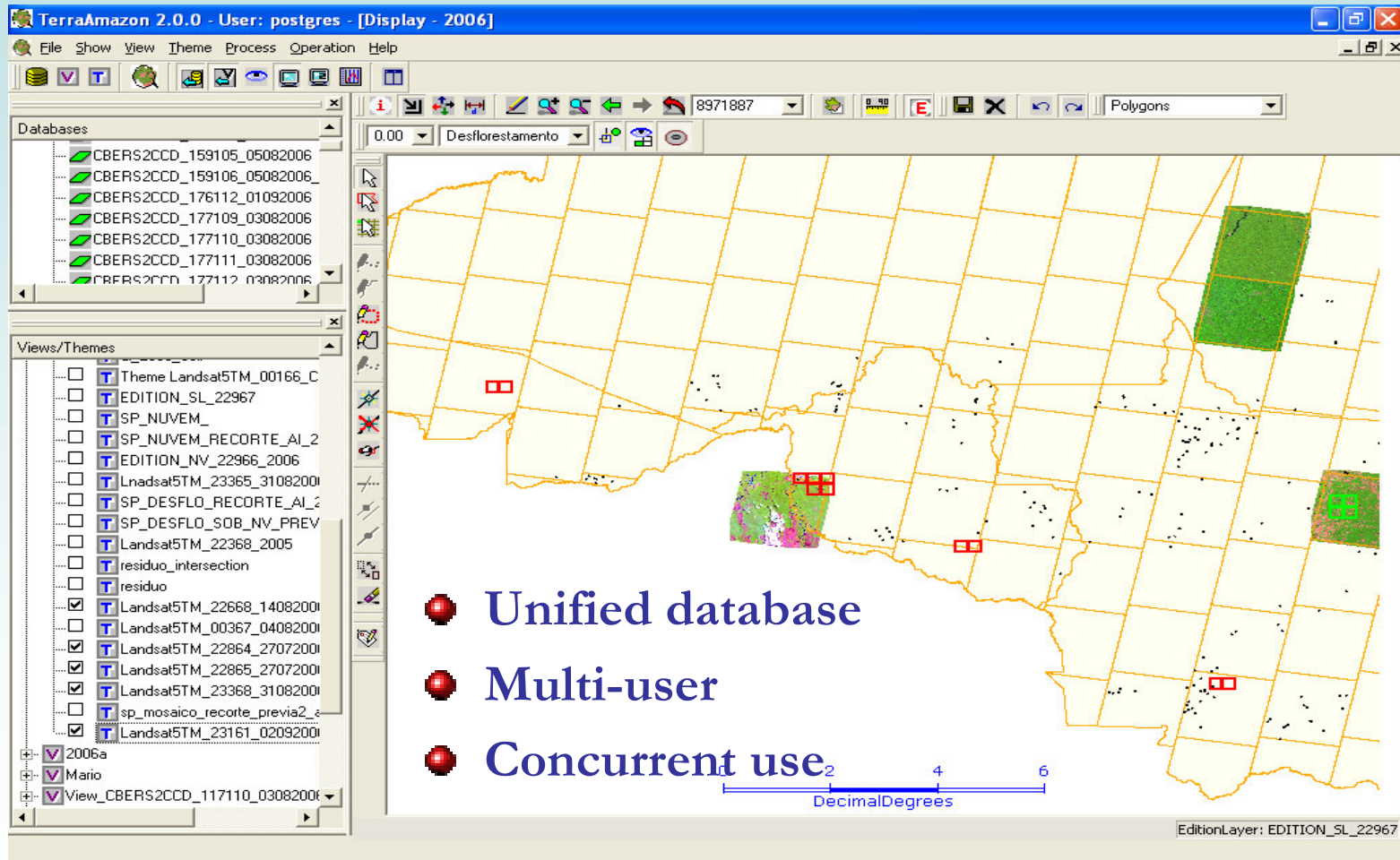
Dissemination

Red cells are blocked and green cells are enable to this user

Drawing a polygon

Methodology

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

Classifying the deforestation polygon

Methodology

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

deforestation defined
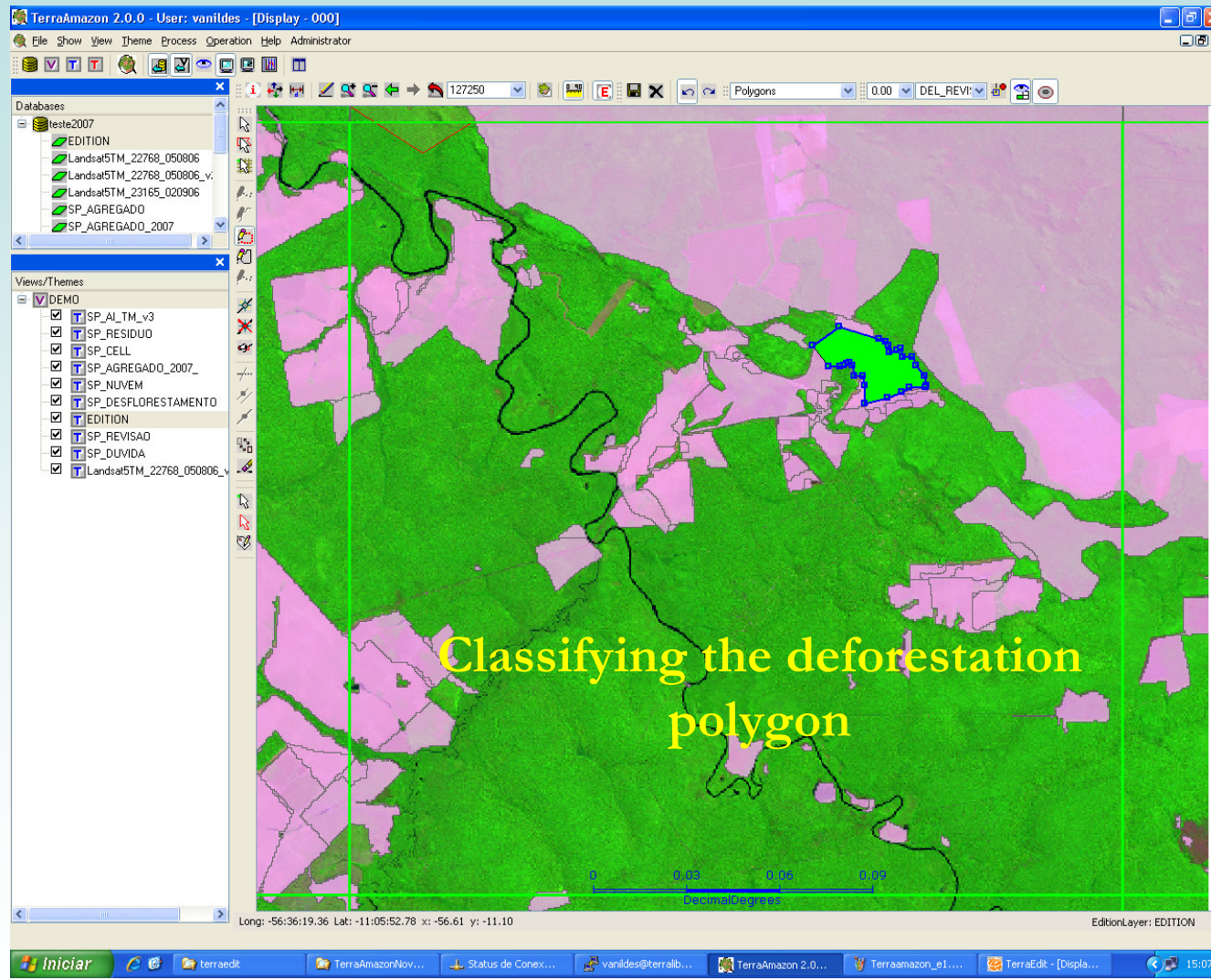
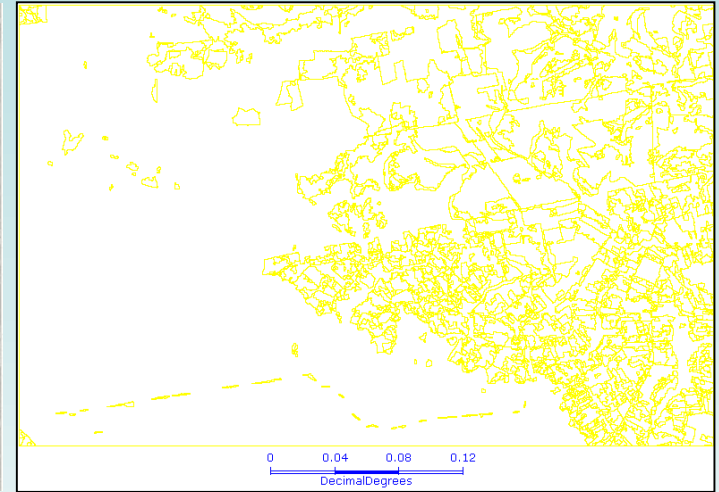Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination
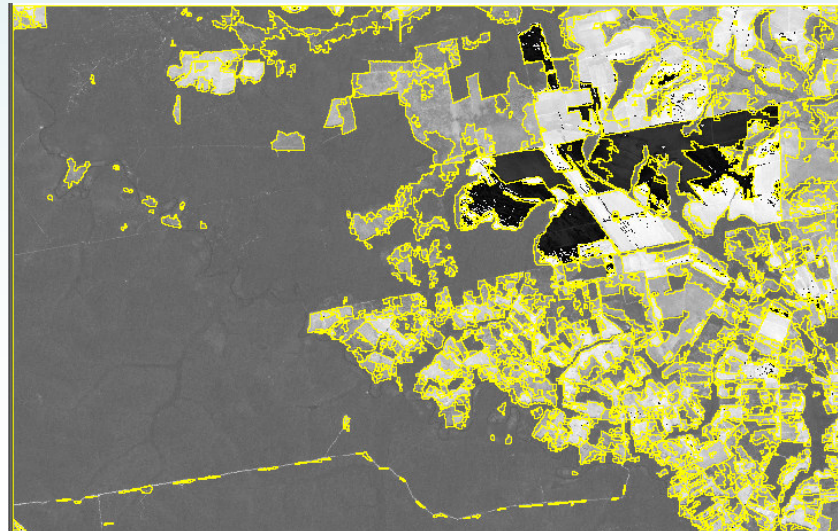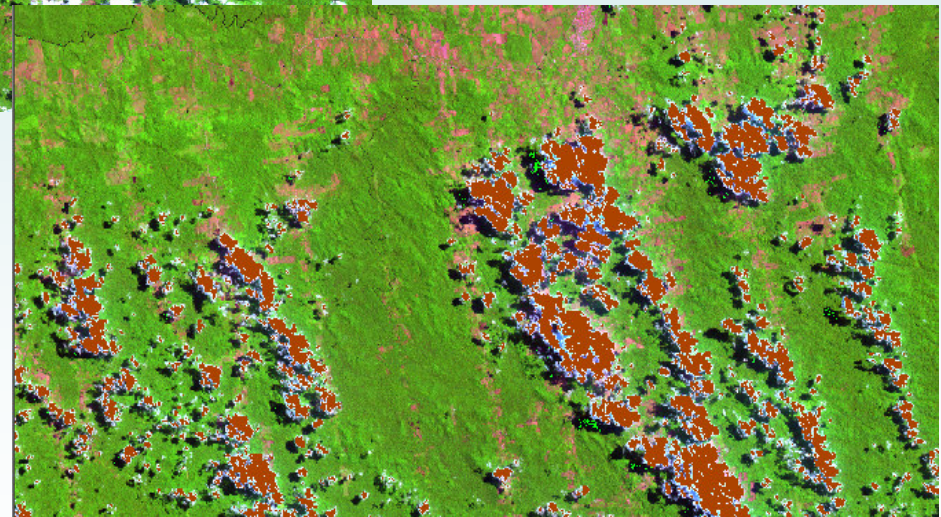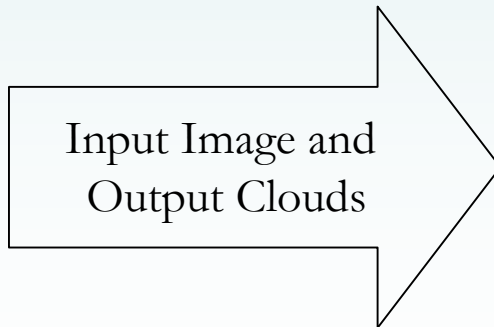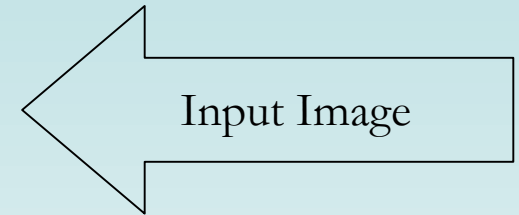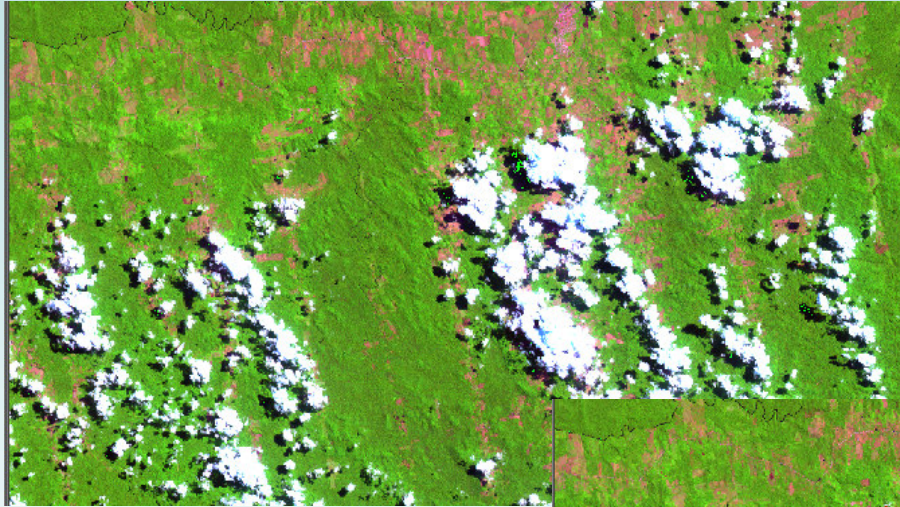
Demonstration...

Methodology

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

- Use same edition tools of interpretation;

- Rejected areas are returned to interpreter;

- Usually short corrections are made;

- Auditor is specialist in remote sensing;

- Check inconsistency and report to coordinator;

Results

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

Final Map Classes:

- ■ Forest
- ■ Deforestarion
- ■ Clouds
- ■ No Forest
- ■ Hydrography

Results
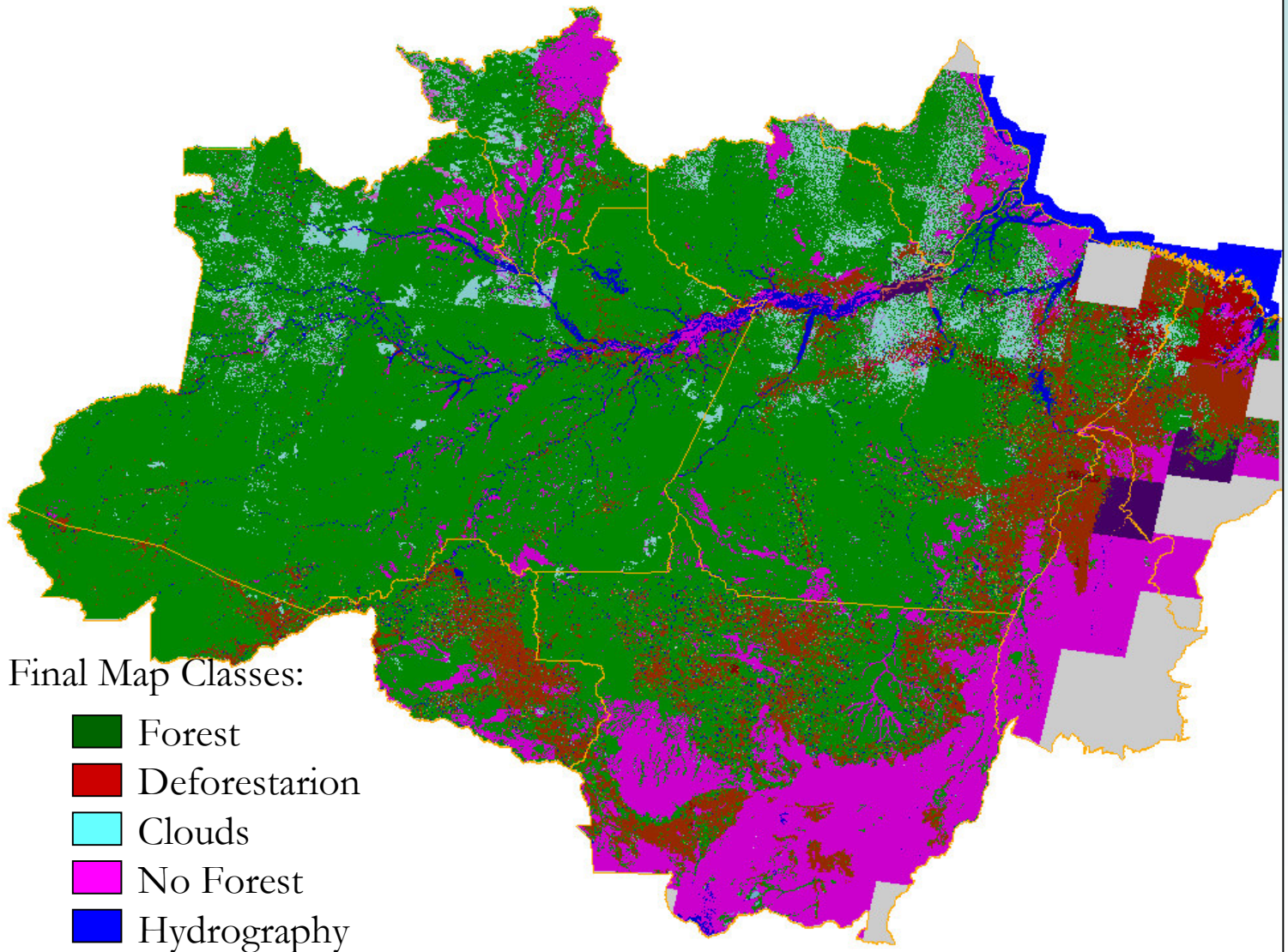
Final Calculated Areas (km²):

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

Clouds

Deforestation

Forest

	A	B	C	D	E	F	G	H	I	J	
1	pathrow	uf	codigo	julday	fstarea	dfsarea	inc	fstclds	dfcld_01	dfcld_02	dfcl
2	157	RR	1	266	3495.70	18.28	0.06	2763.42	0.13	0.00	
3	158	AM	1	234	102.93	0.00	0.00	77.66	0.00	0.00	
4	158	RR	1	234	8956.74	6.95	0.55	4496.22	0.34	0.14	
5	159	AM	1	234	15451.86	17.81	0.17	1518.38	0.29	0.00	
6	160	AM	1	298	24107.75	173.83	0.31	236.35	0.23	0.00	
7	161	AM	1	298	24468.19	30.23	0.14	2074.02	0.00	0.00	
8	162	AM	1	298	22648.12	811.44	7.25	1219.51	0.00	0.00	
9	163	AM	1	250	26689.24	151.22	1.83	285.96	0.00	0.00	
10	164	AM	1	250	27265.96	21.89	0.31	0.03	0.00	0.00	
11	165	AM	1	250	26803.21	106.65	1.08	0.00	0.00	0.00	
12	166	AM	1	234	25016.84	1684.31	161.80	0.00	0.00	0.00	
13	166	RO	1	234	200.37	40.51	0.76	0.00	0.00	0.00	
14	167	AC	1	202	1993.15	3395.00	42.04	0.00	0.00	0.00	
15	167	AM	1	202	2991.47	883.91	48.21	0.00	0.00	0.00	
16	167	RO	1	202	1800.87	1210.77	75.04	0.00	0.00	0.00	
17	257	RR	1	273	347.76	0.42	0.00	287.61	0.00	0.00	
18	259	AM	1	337	2086.72	0.45	0.00	858.35	0.00	0.00	

Results

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

	A	B	E	F	G	H	I	J	K	L
1	UF	ANO	5-10 (ha)		10-25 (ha)		25-50 (ha)		50-100 (ha)	
2			AREA(km²	NPOL	AREA(km²	NPOL	AREA(km²	NPOL	AREA(km²	NPOL
3	AC	1997	236.230	3324	398.185	2614	313.418	913	312.132	448
4	AC	2000	279.629	3977	479.332	3148	370.646	1076	360.807	524
5	AC	2001	127.891	1833	129.857	891	45.492	133	36.466	56
6	AC	2002	144.674	2043	176.826	1193	96.733	285	86.113	124
7	AC	2003	193.225	2804	192.836	1323	85.667	252	61.987	91
8	AC	2004	188.816	2677	222.918	1531	107.918	319	44.158	66
9	AC	2005	2.751	39	3.051	20	1.228	3	0.670	1
10	AC	2006	40.649	525	63.623	436	24.573	73	17.596	26
11	AM	1997	339.328	4678	901.198	5693	991.751	2830	1240.744	1786
12	AM	2000	355.369	5034	562.359	3702	395.594	1154	340.741	501
13	AM	2001	229.321	3323	285.258	1917	183.094	539	172.234	253
14	AM	2002	163.459	2353	173.221	1180	95.826	278	85.505	127
15	AM	2003	256.501	3703	273.423	1858	141.664	416	130.917	195

Historical Series

Import Image

Georeferencing

Mixture Model

Segmentation

Classification

Interpretation and Edition

Auditing

Dissemination

	B	C	D	G	H	I
1	con_path_row	task_id	fase_id	timer_secs	Start Process	End Process
2	157	455	1	6853	10/1/2007 10:01	16/1/2007 07:01
3	157	540	2	3541	25/1/2007 11:01	25/1/2007 12:01
4	158	613	1	19130	6/2/2007 05:02	6/2/2007 12:02
5	158	643	2	7079	7/2/2007 02:02	8/2/2007 08:02
6	159	456	1	7704	10/1/2007 11:01	18/1/2007 08:01
7	159	545	2	3557	25/1/2007 01:01	26/1/2007 05:01
8	160	404	1	9656	18/12/2006 05:12	18/12/2006 08:12
9	160	475	2	5155	12/1/2007 11:01	12/1/2007 01:01
10	161	486	1	20520	15/1/2007 11:01	16/1/2007 10:01
11	161	521	2	1533	22/1/2007 11:01	22/1/2007 01:01
12	162	240	1	2048	23/11/2006 05:11	23/11/2006 06:11
13	162	237	1	28694	22/11/2006 01:11	24/11/2006 12:11
14	162	328	1	8470	8/12/2006 08:12	8/12/2006 11:12
15	162	369	2	14071	13/12/2006 05:12	13/12/2006 12:12
16	162	368	2	1266	13/12/2006 05:12	13/12/2006 11:12
17	162	257	2	17489	27/11/2006 01:11	29/11/2006 12:11
18	163	227	1	12190	21/11/2006 06:11	22/11/2006 07:11
19	163	460	2	5963	10/1/2007 01:01	11/1/2007 06:01
20	164	450	1	440	9/1/2007 12:01	9/1/2007 12:01
21	164	546	2	488	25/1/2007 01:01	25/1/2007 01:01
22	165	223	1	4844	20/11/2006 08:11	20/11/2006 09:11

Management tools: Task Control

LANDSAT - TM

CBERS - CCD

DMC
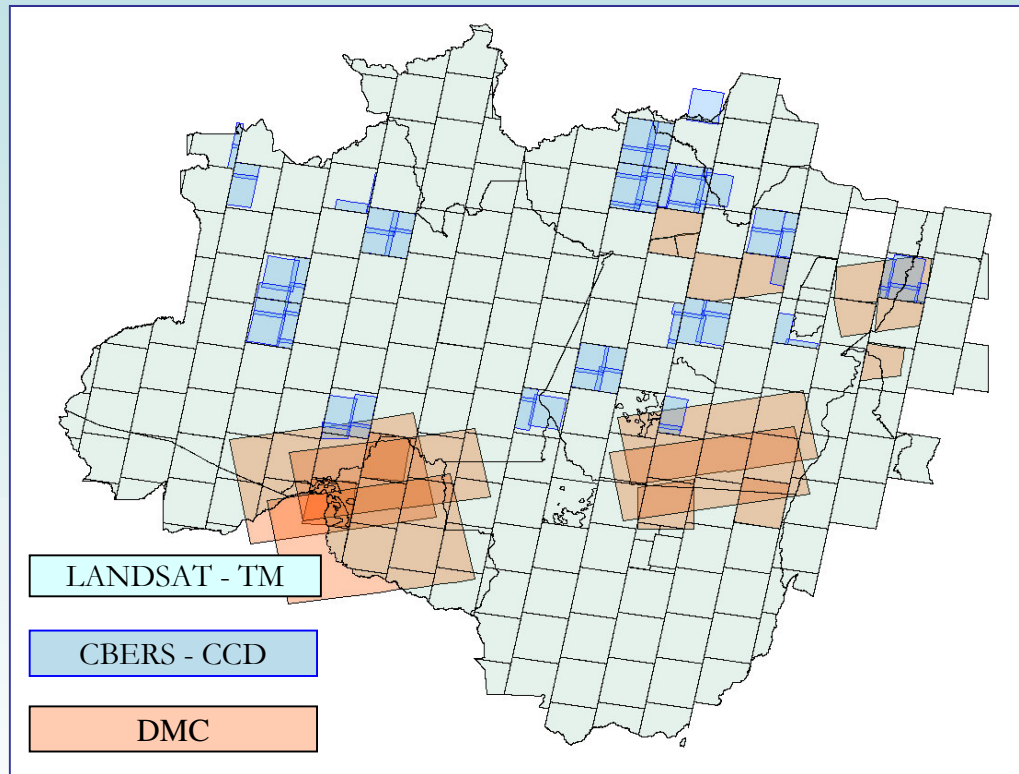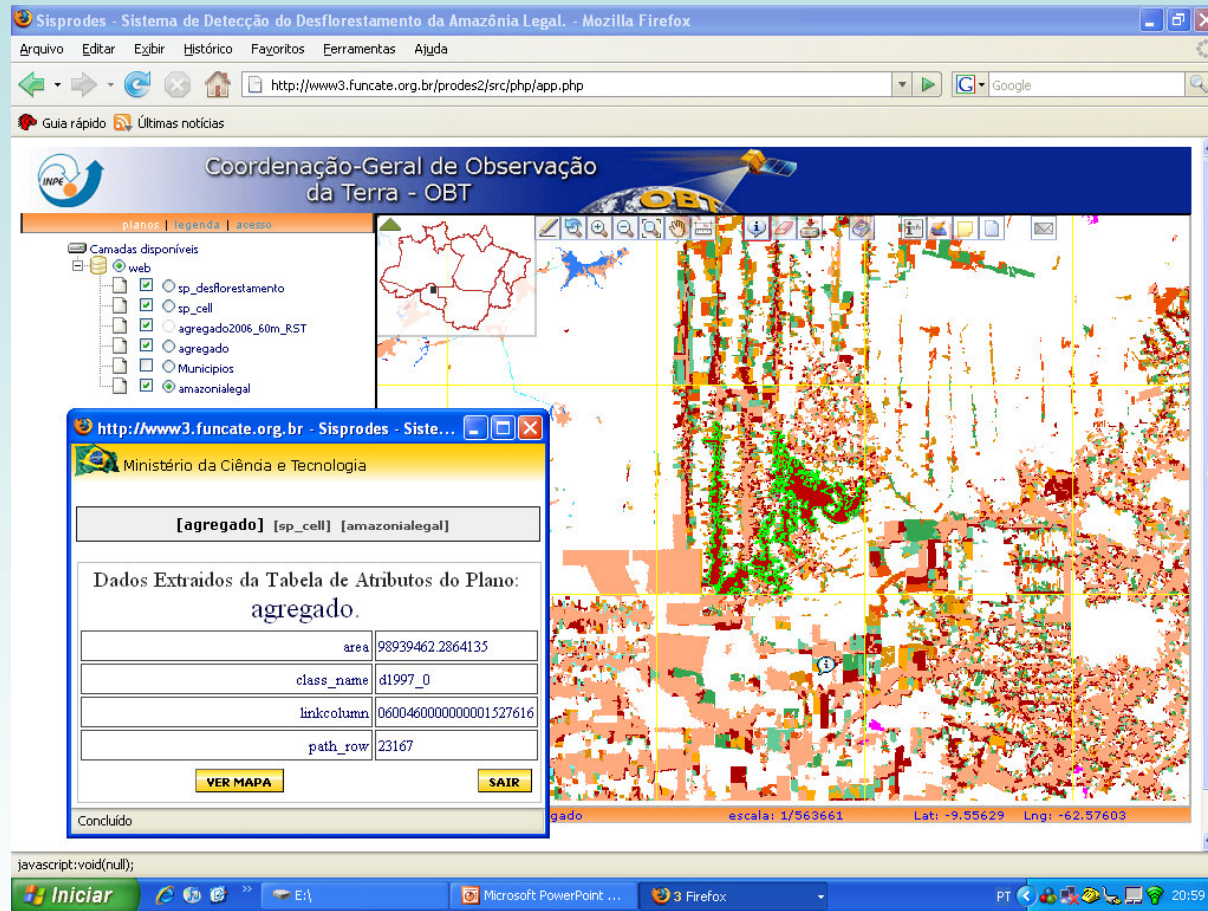
- 221 CBERS images, 223 LANDSAT images and 18 DMC images were used to map deforestation for the 2004-2005 period.

- 70 CBERS images and 211 LANDSAT images were used for the 2005-2006 period.

- Multi-satellites were used to map deforestation in 2005 to minimize cloud coverage impacts.

- Up to 20 concurrent users accessed the system during the interpretation phase in **2006**.

- These users added **213,693** new deforestation polygons and **595,575** new cloud polygons.

- Currently the database stores **2,380,880** polygons of different categories

- The most complex polygon has **69,925** vertices, with the average number of vertices in a polygon being **59**. The average number of holes per polygon is **7**.

- The volume of data stored in the database is **237** gigabytes.
  .

WebSites

Deforestation database: http://www3.funcate.org..br/prodes2

TerraAmazon: http://www.dpi.inpe.br/terraamazon

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FUNCATE Development Group:
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Frederico Bede;

Thank you!