MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

The Brazilian Experience in the Use of Remotely Sensed Data to Estimate CO_2 Emissions and Removals from Forest land

Thelma Krug, Dalton Valeriano et al. (INPE)

Yokohama, Japan, 23-25 February, 2010

BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

Relevance of the LUCF Sector to the Total National CO_2 Emissions

Sector	***1990*** ***(Gg CO_2)***	***1994*** ***(Gg CO_2)***	***% Cont. 94***	***% Var. 90/94***
Energy	203,353	236,505	23,0	16
Industrial Processes	16,949	16,870	1,6	0
LUCF	758,281	776,331	75,4	2
TOTAL	978,583	1,029,706	100,0	5

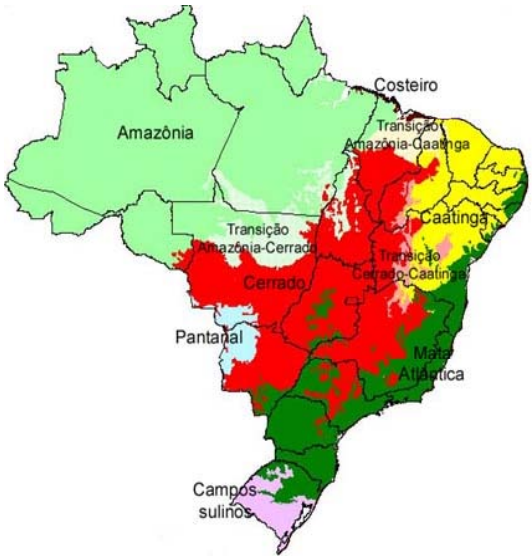
Relevance of the different reporting categories in the 1996 Revised IPCC Guidelines

	1990 ($Gg\ CO_2$)	1994 ($Gg\ CO_2$)	% Cont. 94	% Var. 90/94
Changes in Forest and Other Woody Biomass Stocks	- 45,051	- 46,885	-4,6	-4
Forest and Grassland Conversion	882,477	951,873	92,4	8
Abandonment of Managed Land	-189,378	-204,270	-19,8	-8
CO_2 Emissions and Removals from Soils	110,233	75,613	7,5	-31

Relative Contribution of each Biome to the Net CO_2 Emissions

Biome	*Emissions (Tg C/yr)*	*Removals (Tg C/yr)*	*Net Emissions (%)*
Amazonia	151,7	34,9	116,9 (59)
Cerrado	67,1	15,7	51,5 (26)
Mata Atl.	11,8	0,5	11,3 (6)
Caatinga	10,0	---	10,0 (5)
Pantanal	10,3	2,8	7,5 (4)
TOTAL	250,9	53,8	197,1

Brazilian Biomes



National Forest GHG Inventory

- Second National Inventory based on the GPG/LULUCF
- Intensive use of data and information from a range of remotely sensed sources (optical, radar, airborne)
  - Normally generated for other purposes
- Estimates of changes in carbon stock provided by biome, state, county, soil type
  - *Amazonia*
  - *Cerrado*
  - *Pantanal*
  - *Caatinga*
  - *Mata Atlântica*
  - *Pampas*

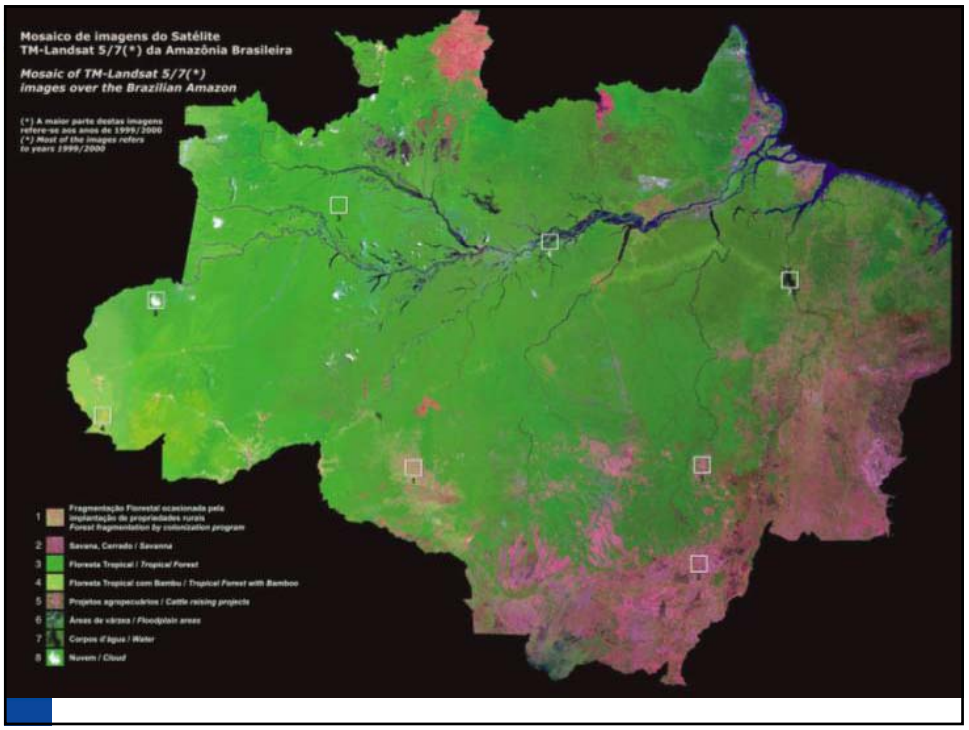
Use of Remotely Sensed Data in Inventories

- Good practice approaches for representing land areas
  - Characteristics
    - ***Adequate*** – capable of representing carbon stock changes and GHG emissions and removals
    - ***Consistent*** – capable of representing management and land-use change over time
    - ***Complete*** – all land area should be included
    - ***Transparent*** – data sources, definitions, methodologies and assumptions clearly described.

Some characteristics of the Brazilian Inventory

- Approach 3 – spatially explicit land representation
- Widely accessible via internet - transparent
- Replicable, thus verifiable (NGOs, Secretaries of Environment)
- Modelling approach (tier 3) for biomass estimation for Amazonia, expanding for other biomes (Werner's point of different results from use of different approaches and tiers)
- Assessment of different approaches and their impact (different models, different data) (Jim's point on huge differences from use of different data)
- Tier 2 for the other biomes (for living biomass)
- Open to comments before finally published

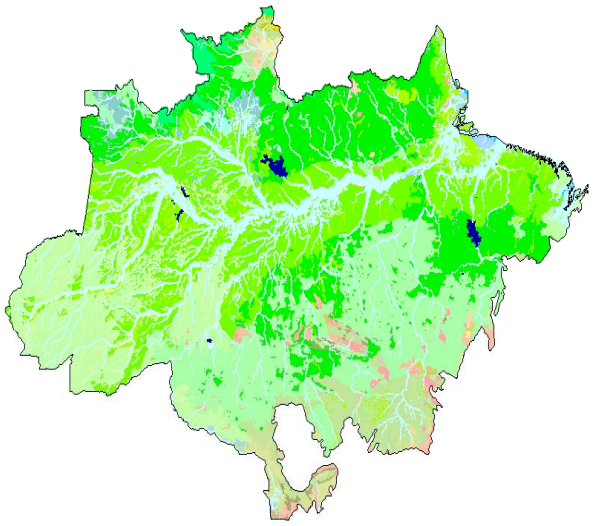
Amazonia


Mosaico de imagens do Satélite
TM-Landsat 5/7(*) da Amazônia Brasileira
Mosaic of TM-Landsat 5/7(*)
images over the Brazilian Amazon
(*) A maior parte destas imagens refere-se aos anos de 1999/2000
(*) Most of the images refers to years 1999/2000
1 Fragmentação Florestal ocasionada pela implantação de propriedades rurais
Forest fragmentation by colonization program
2 Savana, Cerrado / Savanna
3 Floresta Tropical / Tropical Forest
4 Floresta Tropical com Bambu / Tropical Forest with Bamboo
5 Projetos agropecuários / Cattle raising projects
6 Áreas de várzea / Floodplain areas
7 Corpos d'água / Water
8 Nuvem / Cloud

National Forest GHG Inventory - LULUCF

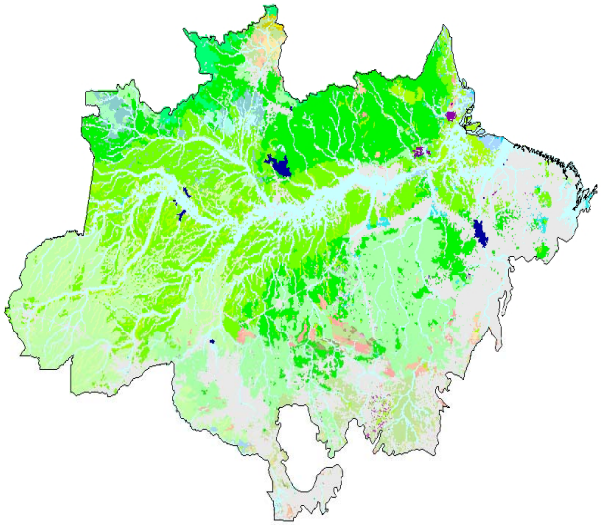
- Total coverage of all biomes with satellite imagery of good spatial resolution (< 30 meters) for each year (1994 and 2002)
  - 492 satellite images each year
  - Stratification of the entire national territory by
    - Land use
      - Forest
        - *Primary forest*
        - *Planted forests*
        - *Regenerated forests (secondary vegetation)*
        - *Selective Logging*
      - Grassland
      - Cropland
      - Wetland
      - Settlements
      - Other
    - Vegetation type (physiognomy)
    - Soil type
    - Municipality (county)
    - Biome

Amazônia
Original Vegetation



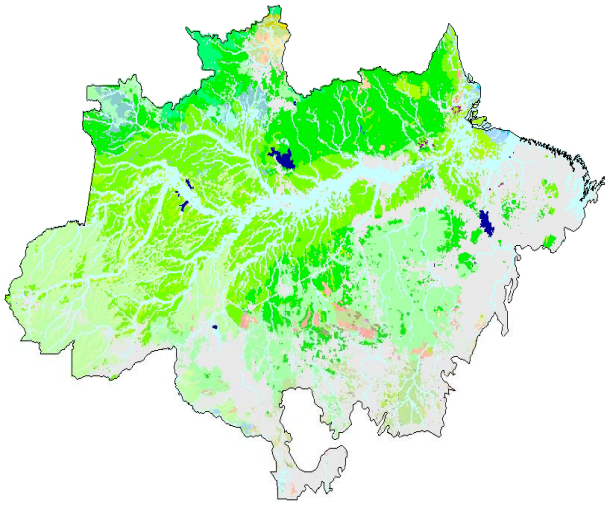
Bioma Amazônia

1994

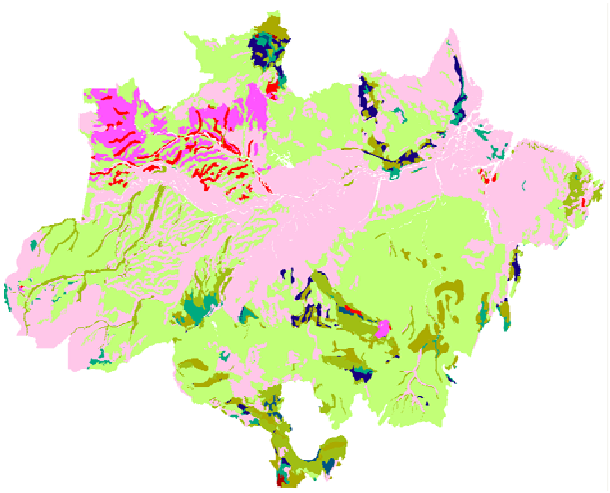


Bioma Amazônia

2002



Amazônia
Soil Map



Number of polygons - 1994 x 2002

- **Amazônia: 808.000 poligons**
  - **366.000 poligons smaller than 25ha**
- **Cerrado: 1.325.000 poligons**
  - **1.012.000 poligons smaller than 25ha**

Amazônia
Area Transition Matriz – 1994 and 2002

	Florestas	Agricultura	Pastagem	Area urbana	Area alagada	Outros	Vegetação Secundária	Reflorestamento	Reservatórios	Total 1994
Florestas										
Agricultura										
Pastagem										
Área urbana										
Área alagada										
Outros										
Vegetação Sec.										
Reflorestamento										
Reservatórios										
Total 2002										

unidade: ha

Use of Remotely Sensed Data in Inventories

For Representing Land Areas (Land use/cover and changes)

- RS data very suitable for Approach 3 – *geographically explicit land-use data*
- GIS helpful to ***combine remotely sensed data with ancillary mapped data*** (vegetation maps, soil maps, municipalities etc.)
- Need to develop a ***method for remote sensing data interpretation*** into land categories using ground reference data
- Limitation of remote sensing depending on the ***land use sub-categories*** (e.g., grassland x secondary vegetation)
- Limitation of remote sensing depending on the ***definition*** used, particularly if thresholds are set (e.g., deforestation, forest degradation)
- ***Accuracy*** of land representation directly related to the spatial resolution of the data used
- Limitation of ***optical*** remotely sensed data and complexities/limitations of radar data use

Use of Remotely Sensed Data in Inventories

Representation of Land Areas

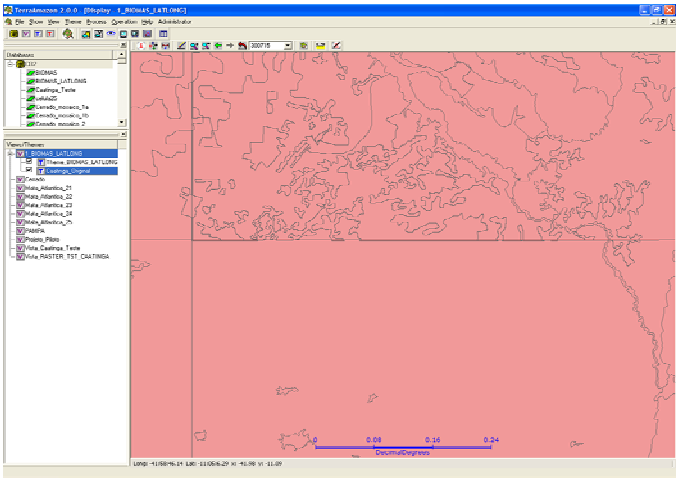
Evaluation of interpretation accuracy

- Facilitated when using remotely sensed data
- Consistency check among different interpreters
- Identification of statistically significant differences

More guidance should be provided on potential sources of uncertainties when using remotely sensed data – not only interpretation.

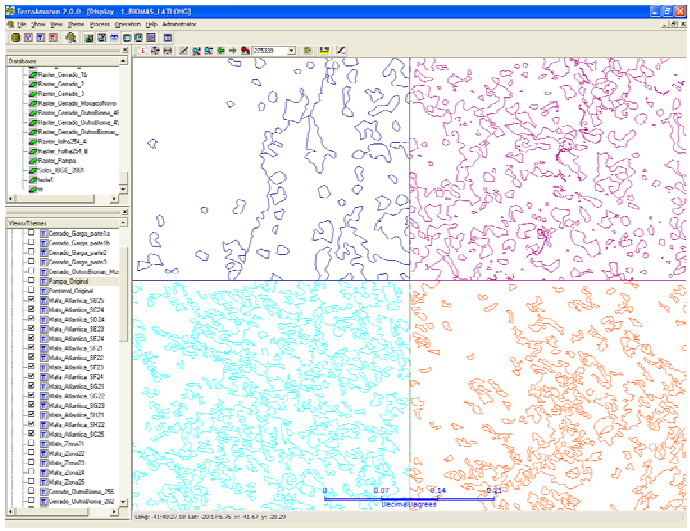
Issues arising from different image interpreters

Caatinga



Issues arising from different image interpreters

Mata Atlântica



Use of Remotely Sensed Data in Inventories

Forest Land

Forest Land remaining Forest Land – FF

- Annual change in carbon stocks from FF
  - Annual change in carbon stocks in living biomass
    - Annual increase in carbon stocks due to biomass growth
    - Annual decrease in carbon stocks due to biomass loss
  - Annual change in carbon stocks in dead organic matter
  - Annual change in carbon stocks in soils

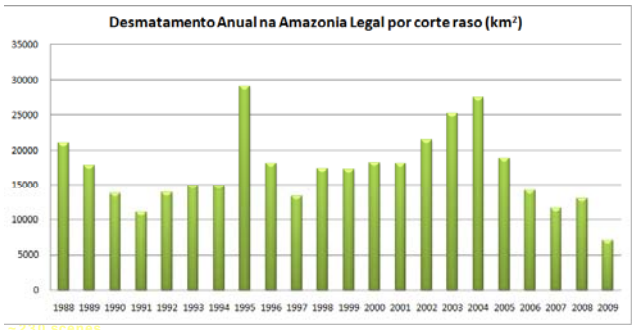
Use of Remotely Sensed Data in Inventories

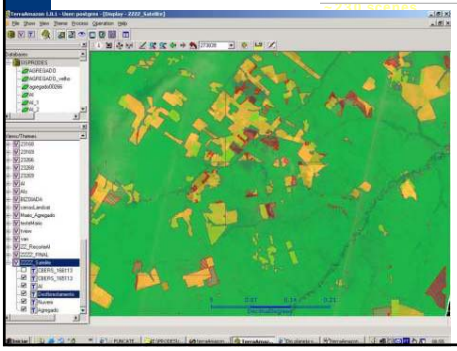
- Annual increase in carbon stocks due to biomass growth - Equation 3.2.4
  - Area of FF by forest type and climatic zone
  - Average annual increment rate in total biomass
- Annual decrease in carbon stocks due to biomass loss - Equation 3.2.6
  - Annual carbon loss due to commercial fellings
  - Annual carbon loss due to fuelwood gathering
  - Annual other losses of carbon
  - Annual other losses of carbon
    - Forest area affected by disturbances
    - Average biomass stock of forest areas
    - Fraction of biomass left to decay in forest

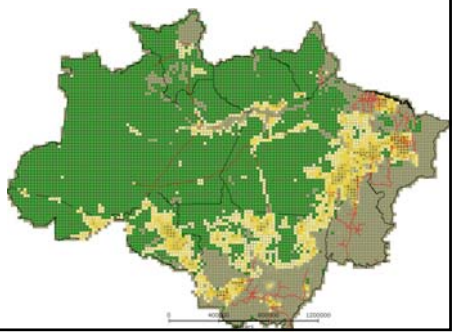
Use of Remotely Sensed Data in Inventories

- Forest land converted to Other Land-Use Categories
  - Remotely sensed data useful to identify forest converted to other land uses – issues of definition, scale
    - *Brazil – use of ancillary data (PRODES, DEGRAD, DETEX)*
  - Remotely sensed data useful to identify forest land converted to cropland, but limited to discriminate between annual and perennial crops unless a multi-temporal set of images is used – ***more guidance?***
  - Restricted use to identify type of crop – need of other ancillary data – statistics (how to use statistics not acquired annually - ***more guidance?***
  - Remotely sensed data useful to identify forest land converted to grassland, but confusion may occur during the first years of conversion – conversion to grassland or abandonment for regrowth? ***more guidance?***

PRODES





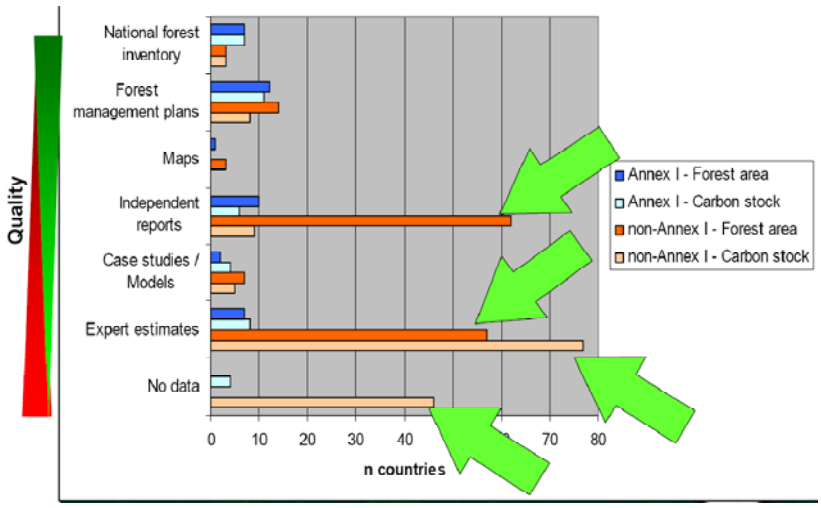


Use of Remotely Sensed Data in Inventories

Estimation of carbon stock changes

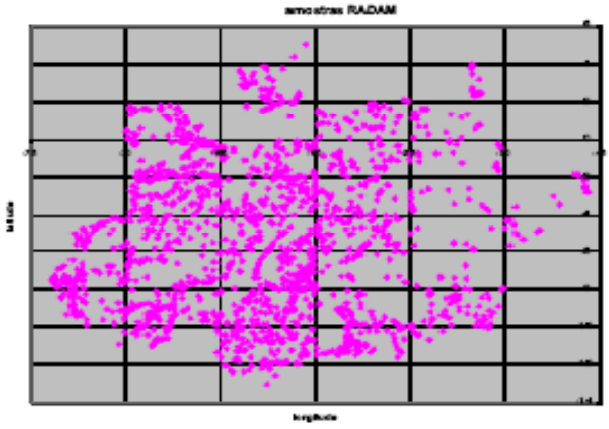
- Still limited use of remotely sensed data to estimate biomass
- Potential remotely sensed data for tropical countries still an academic issue and not completely mature for operational use
- Coupling with ground data important – ***national forest inventories*** still limited in most countries, particularly developing countries
- Brazil (1) – use of ***ground data*** collected in mid-70s (DAP) with allometric equations developed for Amazonia – limitation of the ground data collected, limited access, need for updated data
- Brazil (2) – independent estimate of emissions from Amazonia using satellite data coupled with ground data
  - ***More guidance?***

Data sources used for estimating changes in carbon stock (FAO)



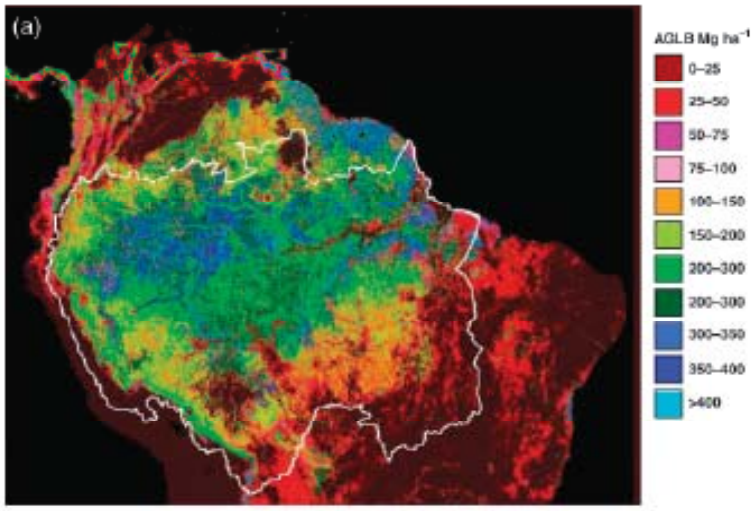
Samples from RADAMBRASIL project

Figura 3.1 - Distribuição das amostras do Projeto RADAMBRASIL



Distribution of aboveground live biomass in the Amazon basin

S. S. SAATCHI*, R. A. HOUGHTON†, R. C. DOS SANTOS ALVALÁ‡, J. V. SOARES‡ and Y. YU*



Deforestation x Forest Degradation – an unresolved issue?

Progressive Forest Degradation

Barlow and Peters (2008)

Traditional selective logging

Uncontrolled logging and fire

Further fires

Final stage ≡ Deforestation

Progressive Forest Degradation

Traditional selective logging

Uncontrolled logging and fire

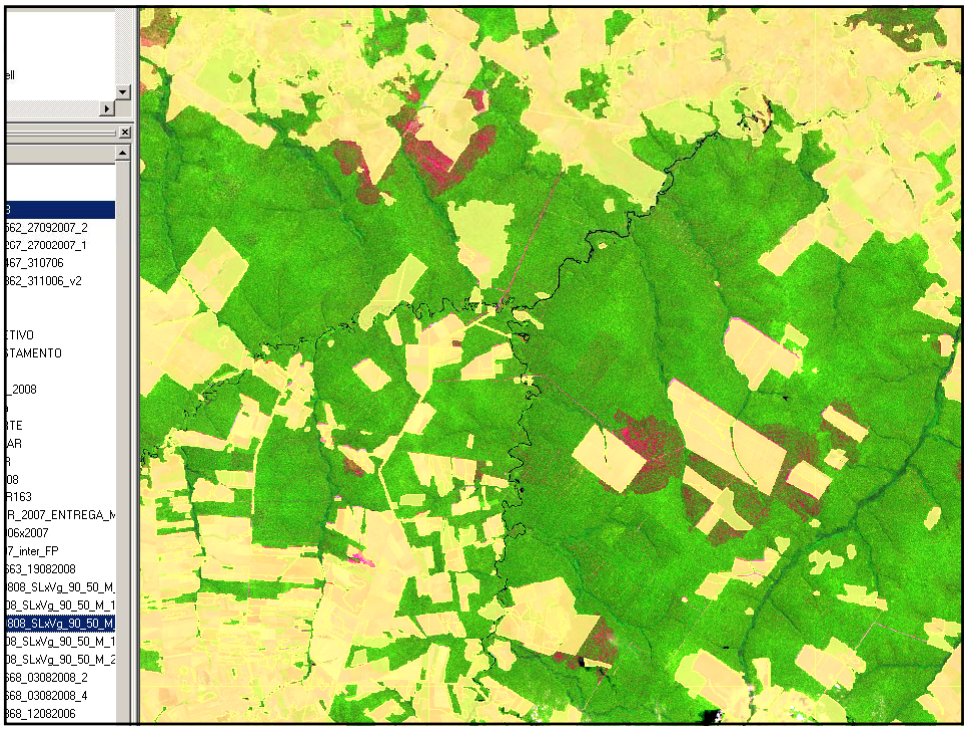
Further fires

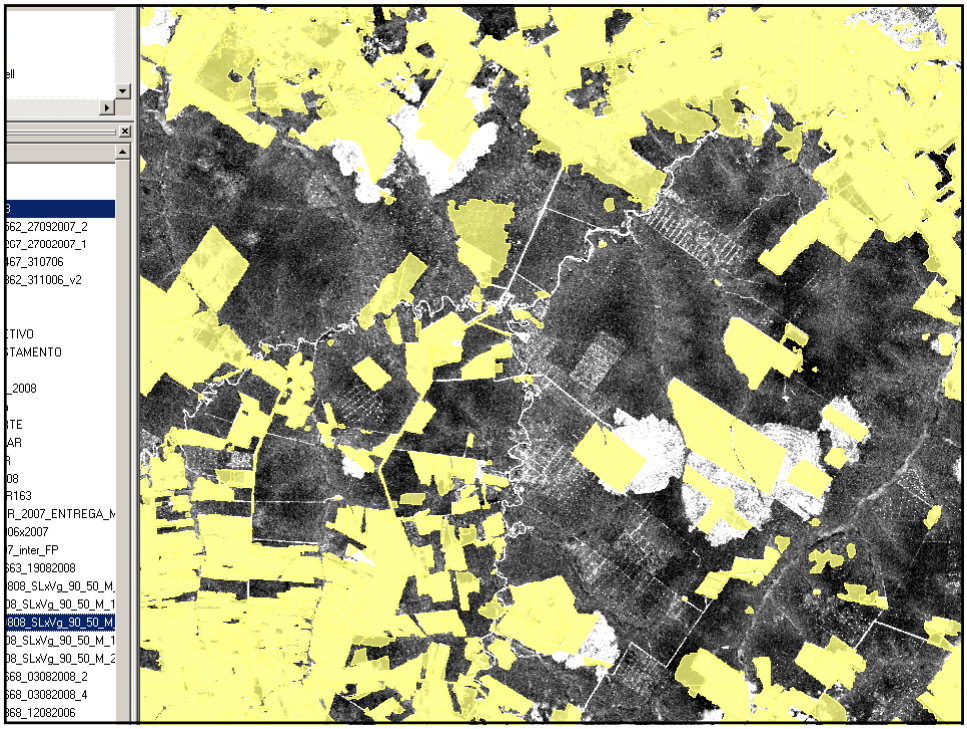
Final stage ≡ Deforestation

Forest Degradation

- Remotely sensed data useful to identify degraded forest areas?
  - Depends on driver (fires, selective logging, fuel gathering?)
  - Depends on the scale of the product used
  - Temporal resolution? Date of image acquisition? Uncertainty?

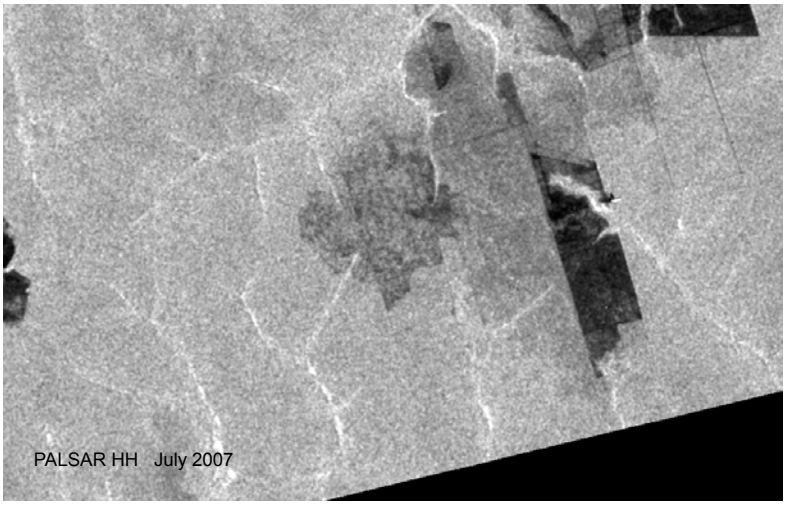
More guidance should be provided?



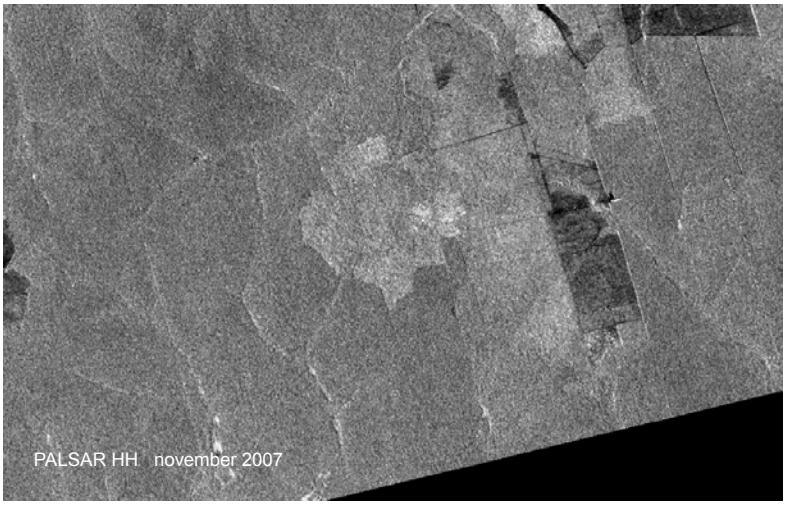


Dynamic signature of deforestation and degradation

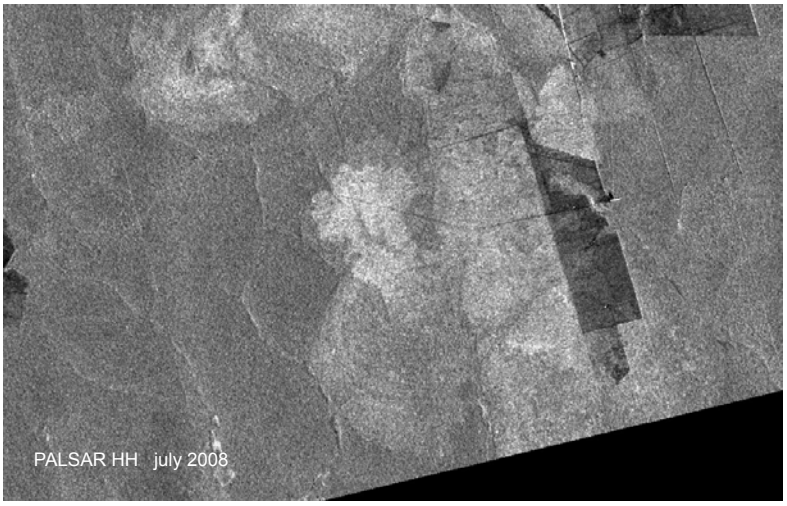
Dynamic signature of deforestation and degradation

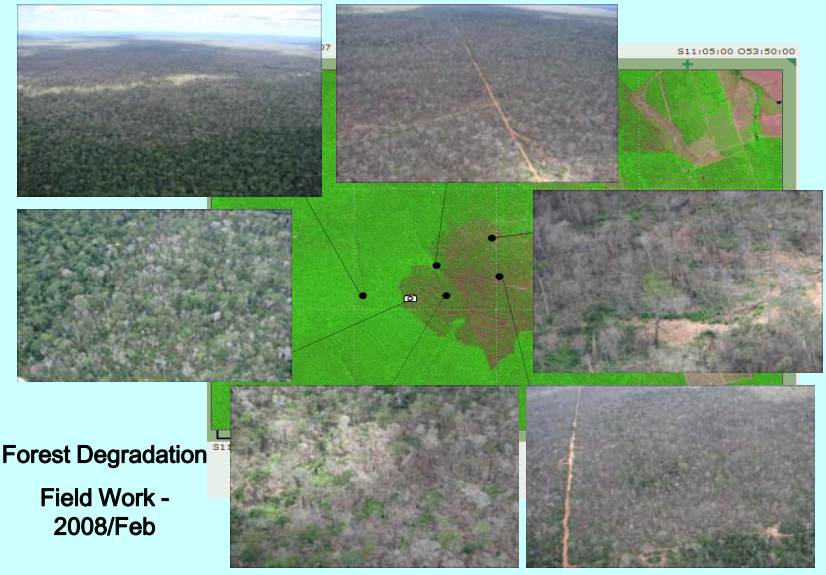


Dynamic signature of deforestation and degradation



Dynamic signature of deforestation and degradation






Thank you