Detection of Selective Logging for Estimating and Monitoring Forest Degradation: methodologies and experiences in Brazil

Thelma Krug
National Institute for Space Research – INPE
Ministry of Science and Technology

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Outline of Presentation

- Deforestation and Forest Degradation
  - Definitional Issues and Implications
- Estimating emissions
  - from deforestation
  - from forest degradation
- Challenges and issues related to Monitoring
  - deforestation
  - forest degradation

Deforestation and Forest Degradation: definitional issues

- Choice of definition has implications on our ability to estimate emissions from deforestation and from forest degradation

- **ANNUAL RATE** of **GROSS DEFORESTATION**
- **DEFORESTATION**: clear cut areas, normally converted to other land uses; binary approach 0 (clear cut) or 1 ("intact" forest)
- **ANNUAL** allows for more a precise annual estimate of clear cut areas using satellite imagery of high resolution (30 meters or less)
  - No need for ground checking but sometimes confusion to associate the bare soil response in satellite imagery due to human activities or natural events; the more even pattern of man-made clear cut helps to discriminate anthropogenic from non-anthropogenic interference
- **GROSS** implies a one-shot look in time (emissions estimates assume instantaneous release of carbon to the atmosphere)
- The **RATE** means that the estimates are adjusted for different imagery dates and for cloud covered areas

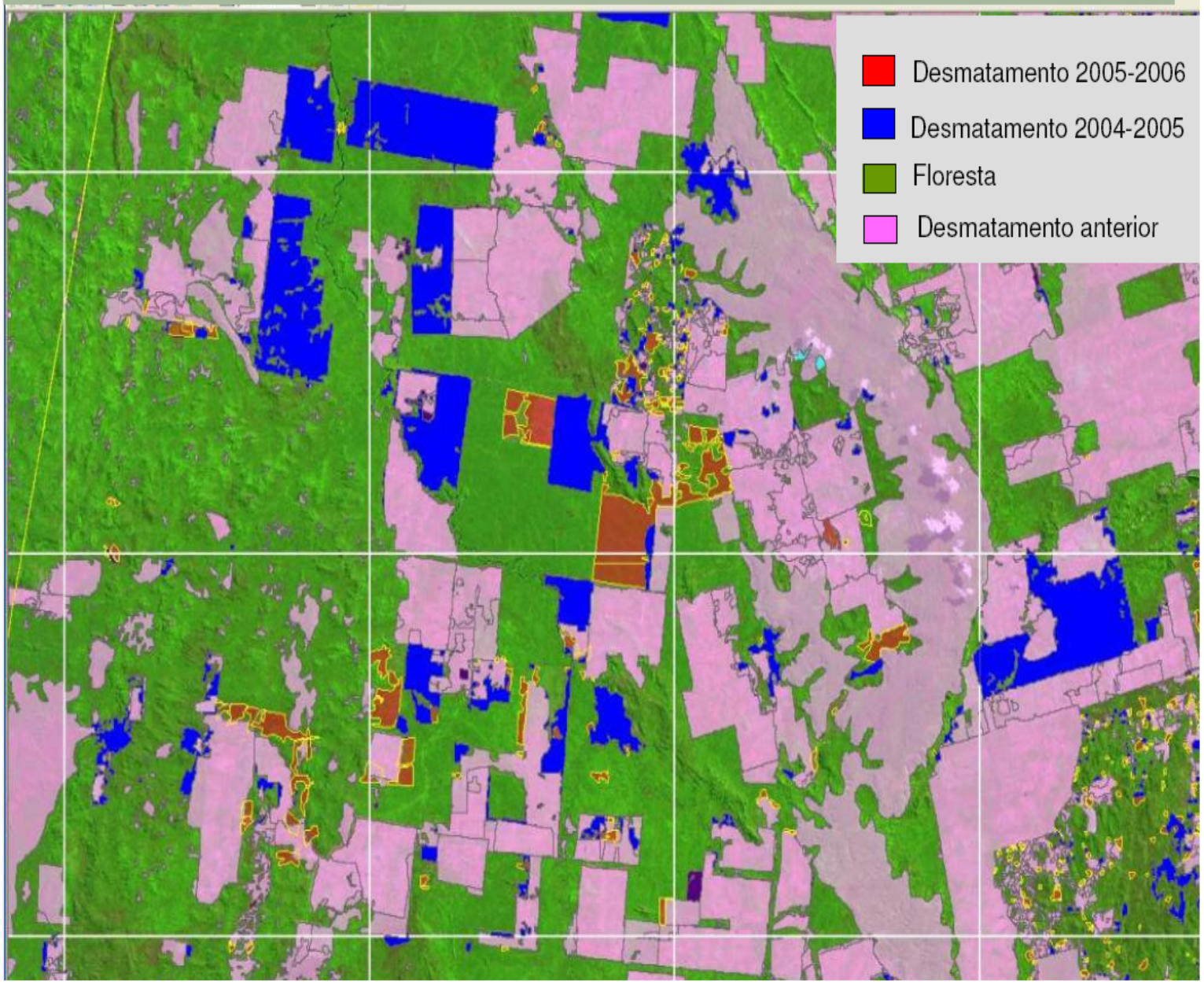
Deforestation and Forest Degradation: definitional issues

- *Issues*: if the definition of deforestation entails a change in forest parameters below given thresholds
  - Challenge when using readily available, simple, wide spread remotely sensed data
  - Increases confusion with other land covers
  - Increases the uncertainty associated with the estimate

Deforestation and Forest Degradation: definitional issues

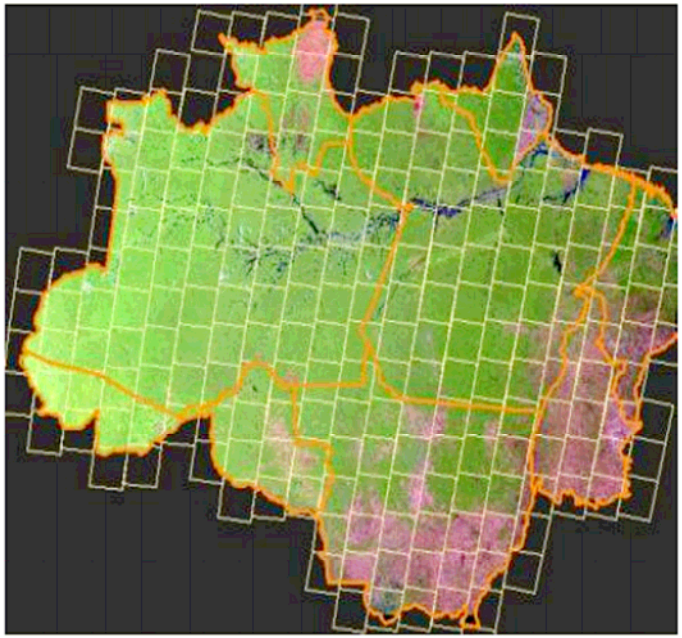
- *Message 1*
  - Depending on the definition used (0 – 1; gross – net) and assuming the same level of confidence in the estimates, more or less refined methods will need to be applied. Tools exist, but ability to readily use them may be a challenge, and cost may rise – implications in capacity building (radar technology, LIDAR, airborne sensors).

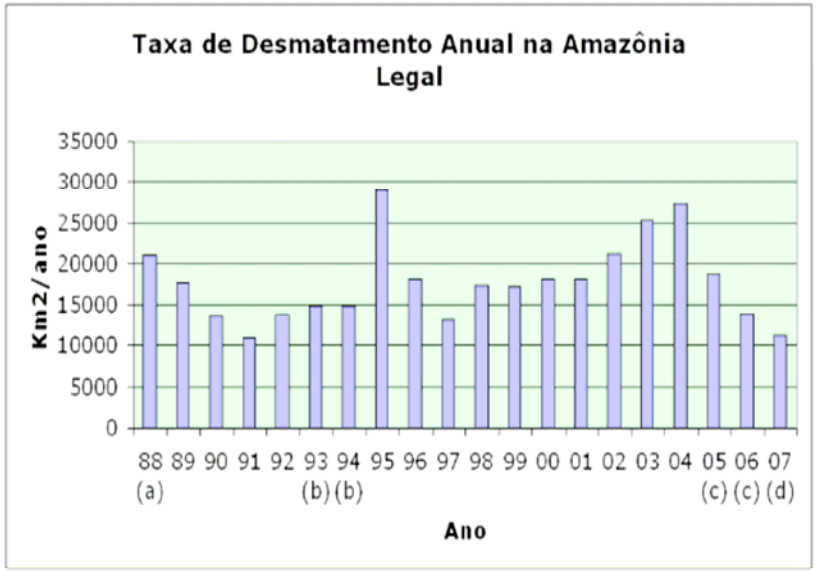
PRODES - Cumaru do Norte (PA)



PRODES

Taxas anuais de desmatamento, km2/ano





20 anos, sem descontinuidade desde o governo Sarney

Taxa de desmatamento anual na Amazônia Legal (km2/ano)

		#imgs/ano	161	191	207	211	211	211
Estados\Ano	**00**	**01**	**02**	**03**	**04**	**05 (c)**	**06 (c)**	**07 (d)**
Acre	547	419	762	1061	729	539	323	136
Amazonas	612	634	881	1587	1211	752	780	582
Amapá		7	0	25.00	46.00	33.00	30	0
Maranhão	1065	958	1014	993	755	922	651	631
Mato Grosso	6369	7703	7892	10405	11814	7145	4333	2476
Pará	6671	5237	7324	6996	8521	5731	5505	5569
Rondônia	2465	2673	3067	3620	3834	3233	2062	1465
Roraima	253	345	84	439	311	133	231	306
Tocantins	244	189	212	156	158	271	124	59
Amazônia Legal	**18226**	**18165**	**21238**	**25282**	**27379**	**18759**	**14039**	**11224**

www.obt.inpe.br/prodes

Monitoramento do Desmatamento

Floresta

Corte raso

Corte raso – final do processo de desmatamento

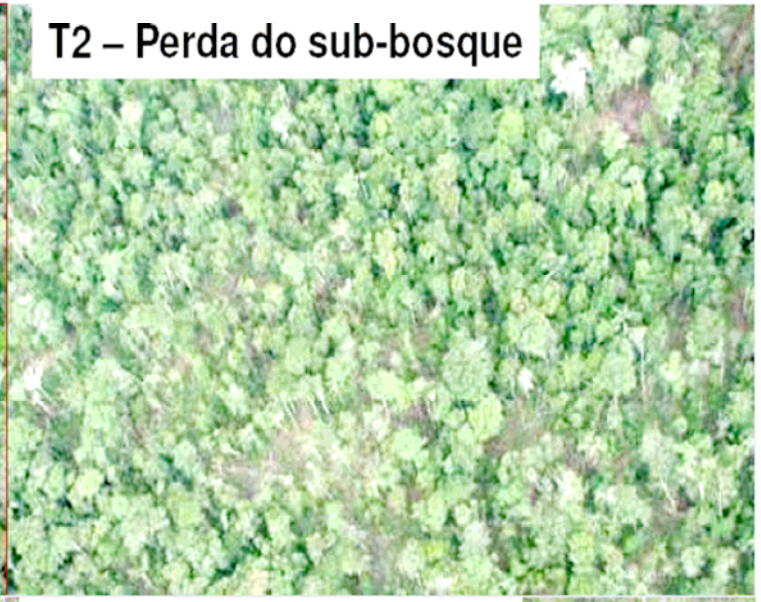
Monitoring the forest cover

- DETER – identifies "anomalies" in the primary forest cover using more coarse resolution satellite data (MODIS, 250 meters)
  - Geo-referenced information sent to the enforcing governmental entity (IBAMA) every two weeks
  - Works like an early deforestation "warning system"
  - Guides command and control operations
  - Indicator of potential areas in process of deforestation
  - **Early action may lead to reduced emissions from deforestation – requires law enforcement, when appropriate.**

Degradação progressiva

T1 – Retirada de madeira

T2 – Perda do sub-bosque



T3 – Perda parcial do dossel

T4 – Perda total do dossel

tempo

DETER – alerta

DETER – alerta

DETER - alerta
inclusão no PRODES

Degradação progressiva

Barlow and Peres (2008)

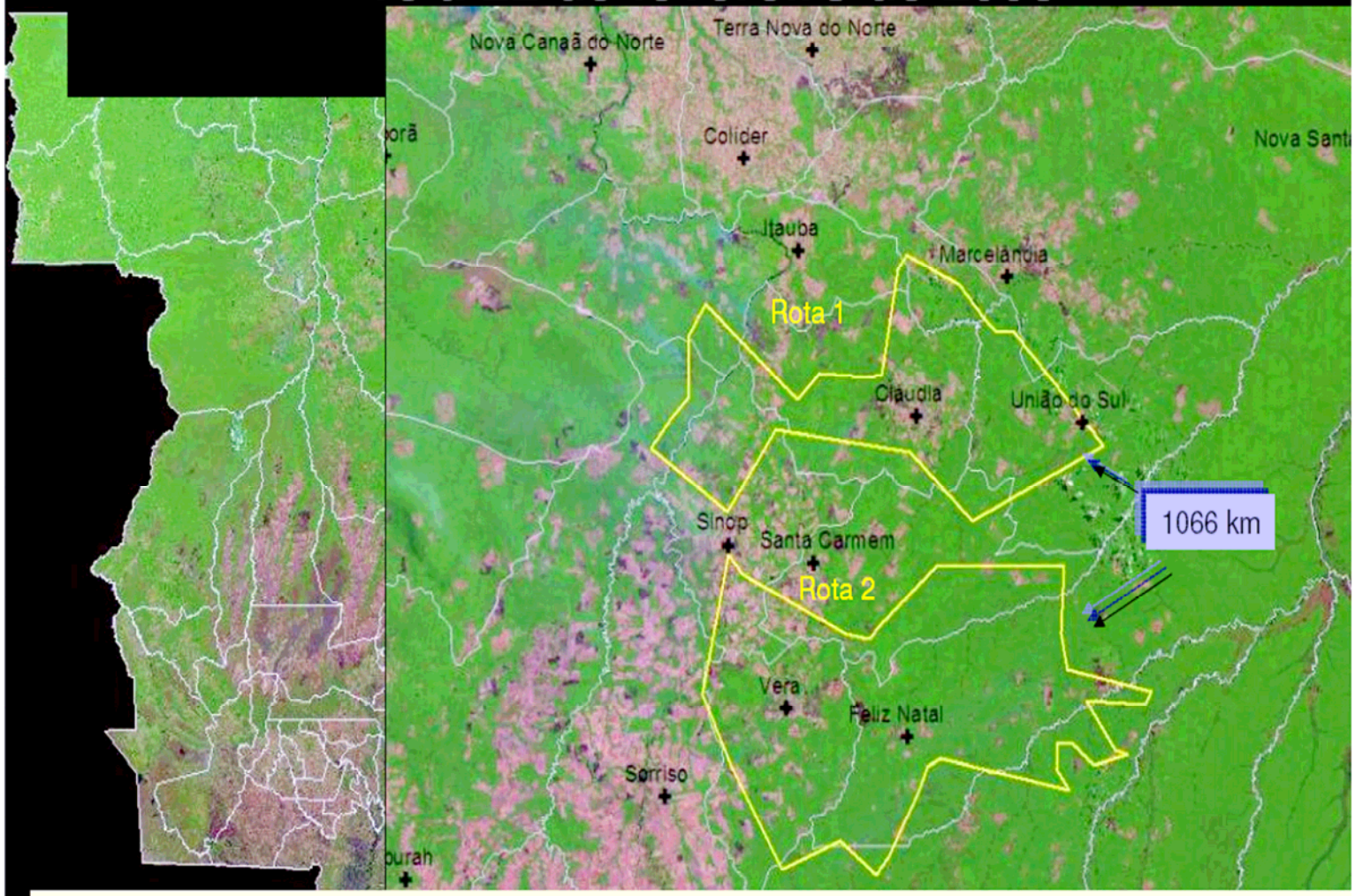
Extração seletiva de madeira

Retirada de madeira e queimada

Recorrência de Queima

Corte raso

Região de Sobrevôo para verificação do DETER
18 a 22 de fevereiro de 2008



40 pontos – 36 de degradação acentuada e corte raso, 4 em início de degradação

Monitoring the forest cover

- Most of the DETER alerts in degraded areas correspond to high intensity forest degradation.

- Initial and intermediary stages of forest degradation are not detected with the same efficiency.

Deforestation and Forest Degradation: definitional issues

- Choice of definition has implications on our ability to estimate emissions from deforestation and from forest degradation
- Forest degradation: a direct, HUMAN INDUCED, LONG-TERM LOSS (persisting for X years or more) or at least Y% of forest carbon stocks (and forest values) since time T and not qualifying as deforestation.
- HUMAN INDUCED: more difficult to discriminate using satellite imagery
  - Some types of human induced changes in the forest cover may have a similar response in satellite imagery than that due to seasonal variations, or diseases and pests, and climate change (drought stress, temperature increase).

Deforestation and Forest Degradation: definitional issues

- Choice of definition has implications on our ability to estimate emissions from deforestation and from forest degradation
- **LONG-TERM LOSS** (persisting for X years or more) or at least **Y% OF FOREST CARBON STOCKS** : implies the need for a multitemporal approach to characterize the persistent loss of carbon stock.
- Not all types of degradation can be identified using the available remotely sensed data from orbital platforms (satellites) or even through airborne sensors.
  - e.g., changes in understorey cover (due to fires, early stages of degradation activities, even selective logging)
- **Current remote sensing can not provide a reliable estimate of changes in carbon stock in areas not moderately or intensely degraded.**
- **Distinct from deforestation, forest degradation does not entail a change in the area of forest cover. The final stages of degradation may lead to deforestation. Challenges to estimate changes in forest parameters that characterize different stages of forest degradation.**

Issues related to selectively logged areas

- .. whereas the different forms of remote sensing are very useful tools for estimating deforestation, they are far less so for assessing degradation which most often calls for observations on the ground.

- …it is unlikely that the current suite of optical sensors can fully identify all types of degradation (Thenkabail *et al* 2004, Fuller 2006) without innovative methods coupling satellite imagery with ground-based observations (Foody and Cutler 2003, Fuller *et al* 2004).

Issues related to selectively logged areas

- Measuring the extent of forest degradation and forest management is much more difficult than measuring deforestation (DeFries *et al* 2007). There are a range of canopy densities and ecosystem types across the tropics. This natural variation in forest cover can be due to underlying biophysical elements (e.g. semi-xeric, semi-deciduous, shrublands, limiting soil conditions such as the white sand forests of the Amazon). To many satellite sensors these ecosystems appear similar to degraded areas of neighboring forest. Human intervention in these more open canopies is very difficult to distinguish. This type of confusion could be alleviated to a degree by having an accurate and detailed vegetation map of these various natural canopy types (e.g. Josse *et al* 2007, Navarro and Ferreira 2007), something that many rainforest nations lack. Rapid forest growth in moist tropical areas can lead to a perceived dense forest cover, a few years after selective logging or in a forest made up of low density early successional species. These perceived 'intact' forests have less biomass and thus their deforestation or forest degradation will result in lower carbon emissions than a truly 'intact' forest.

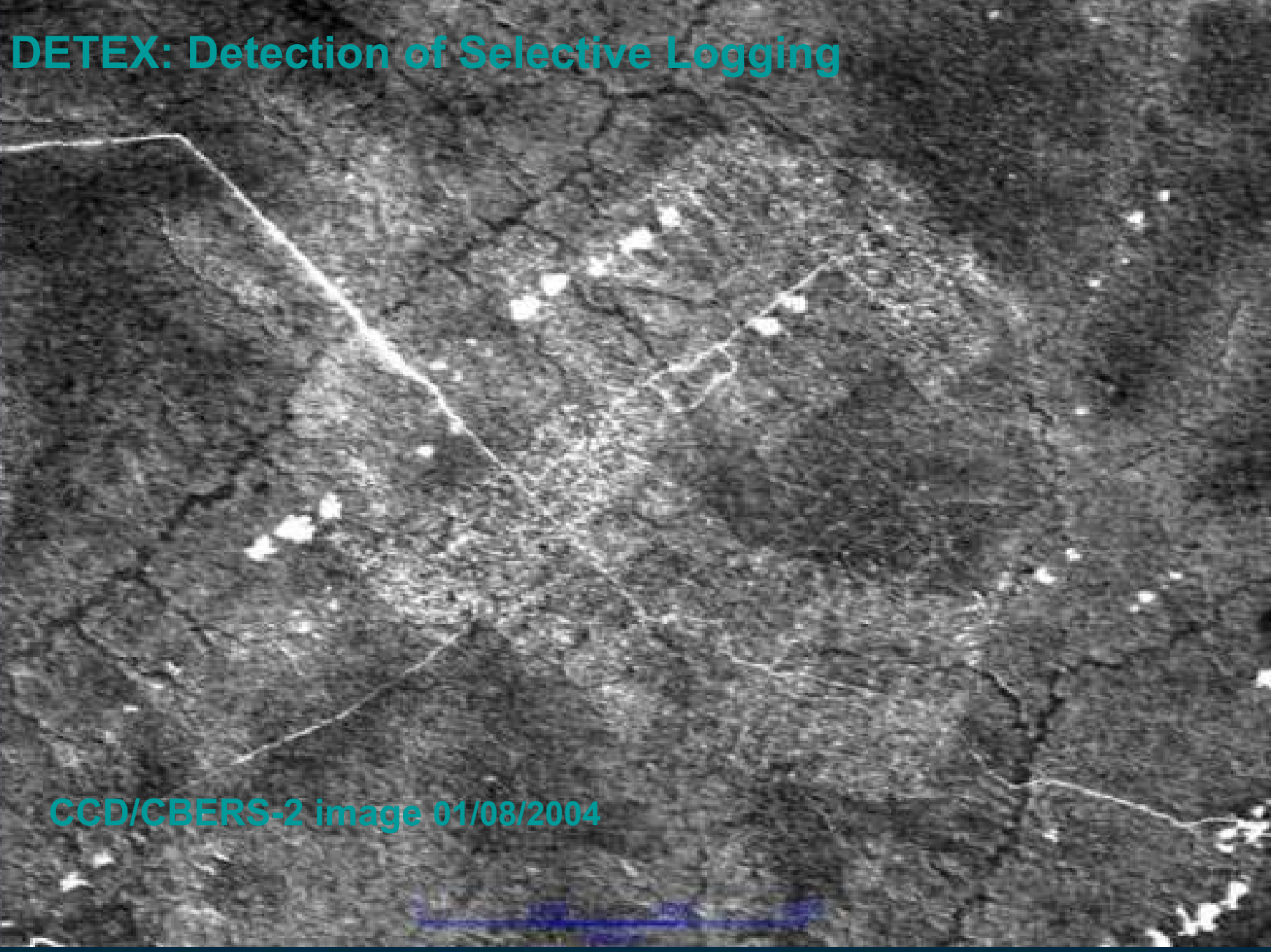
Issues related to selectively logged areas

- An ideal way to identify degradation is to analyze annual time series of Landsat imagery to see the transitions. Unfortunately this is very difficult to do with existing data because high-resolution imagery like Landsat is not recorded frequently enough to provide the needed cloud-free imagery (Asner 2001). Even light clouds or haze over tropical forests can be a problem because it is often confused with degraded forests during satellite image classification. Coarse resolution imagery (e.g., MODIS) has sufficient temporal frequency for a time series (ideally multiple images per year to distinguish degradation from effects of seasonality). However, at coarse resolution much forest degradation, which is often small scale, can be missed.

Estimating emissions from selective logging: a different process of forest degradation?

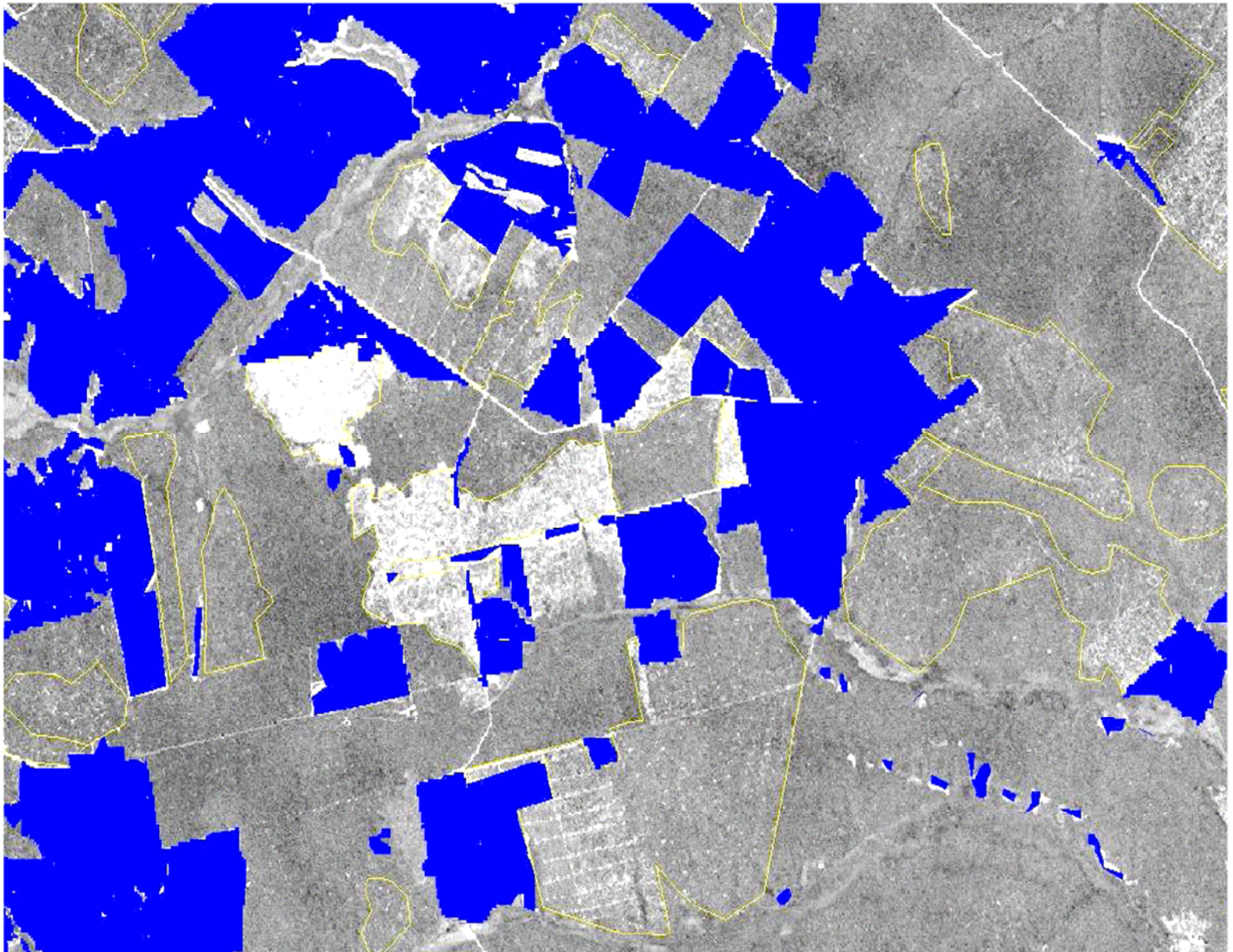
- The only experience in Brazil in relation to assessing forest degradation using satellite imagery relates to selecting logging
  - Optical systems (Landsat, CBERS, SPOT)
  - Radar systems (ASTER, RADARSAT, ALOS)

DETEX: Detection of Selective Logging



CCD/CBERS-2 image 01/08/2004

Degradação florestal por exploração madeireira (Marcelândia –MT)



Selective Logging

- Multitemporal study (1988 – 1999)
- Identification and mapping of areas under selective logging in optical satellite imagery of high resolution (30 meters or less)
- Follow up of the fate of the selectively logged areas
- Annual assessments of all imagery
  - 30% of the selectively logged areas were abandoned to regrow (in early stages of logging); logging scars could not be identified in the imagery after an average of 4 years
  - 30% of the areas converted to deforestation
  - 40% - not able to identify precisely the fate, particularly in the more recent logged areas (1988 or 1989)

Issues related to selectively logged areas

- Estimation of the area under selective logging
- Discrepant figures depending on the definition adopted
  - Krug *et al.* = area of the polygon where selective logging activities are identified
  - Skole *et al.* = same as Krug et al. + buffer (150 – 200 meters around polygons)
  - Nepstad *et al.* = survey at wood millers (wood volume converted to corresponding area)

Issues related to selectively logged areas

One important omission is selective logging for timber, says Asner. In 2005, his team determined the fraction of green reflectance from each Landsat pixel, aided by considerable fieldwork to calibrate how nonvisual light frequencies could inform that calculation. They concluded that Brazil was omitting a whopping 12,000 km2 or more of so-called selectively logged forest areas per year (*Science*, 21 October 2005, p. 480). Asner fears that any system rewarding efforts to halt deforestation could miss a substantial source of emitted carbon if selective logging is not included. Others believe that logging has less of an impact. Skole says Asner could have mistaken thin forests or wetlands for logged forests because their infrared image can "mimic … a logged forest." He also notes that many logged areas grow back. INPE estimates that the per hectare emissions from selective logging are 2% of those from clear-cutting.

Issues related to selectively logged areas

- **Estimating emissions from selectively logged areas**
- **Complex, since it is necessary to identify the fraction of forest cover affected**
- **Most of the time a progressive process that ultimately leads to clear cut – but not always.**
  - **May be simplistic to assume that all selectively logged areas are just stages leading to deforestation**
  - **A decrease in carbon stock in any given forest area does not necessarily imply a human induced degradation process**
    - **Natural forest degradation processes will likely become more evident as climate changes (diebacks, greater tree mortality, pest attacks…).**
    - **May be part of sustainable forest management practices**

Issues related to selectively logged areas

- Relevant degradation processes lead to deforestation at some point in time, and non relevant degradation processes are normally followed by natural regeneration…

  - FAO. 2001. *Global Forest Resources Assessment* FRA *2000 – Main report*. Rome

Monitoring selective logging

- **DETEX – identifies "anomalies" in the primary forest cover that can be associated with selecting logging using medium resolution satellite data (MODIS, 250 meters)**
  - **Geo-referenced information sent to the enforcing governmental entity (IBAMA) every two weeks**
  - **Works like an early selective logging "warning system"**
  - **Guides command and control operations**
  - **Indicator of potential areas in process of forest degradation**
  - **Early action may lead to reduced emissions from forest degradation due to selective logging activities – requires law enforcement, when appropriate.**

Issues related to selectively logged areas

- *Message 2:*

  - Only a representation of land cover as a continuous field of several biophysical variables can lead to an accurate detection of forest degradation.
    - Strong interaction with climatic fluctuations
  - Repetitive measurements of spectral, spatial and temporal indicators of the land surface have to be performed.

Further areas of work

- What assumptions will have to be made to reliably estimate emissions from forest degradation and demonstrate their reduction?
  - Will it be necessary to assume, for instance, in the case of selective logging activities, that these activities will ultimately lead to full clear cut (deforestation)?
    - Or only a fraction of these activities will?
      - In this case, how to estimate this fraction? How to estimate the degree of degradation that would occur in the absence of REDD?
        - Use of multi-temporal imagery?
        - What type of imagery is necessary and what is the time frame necessary for the assessment?
  - Should one assume a BAU scenario?
  - How to estimate the uncertainties associated to the reduced emissions from forest degradation?
- How to estimate and verify the reduced emissions from forest degradation?

Monitoramento da Amazônia: 2005-2015