Joint Research Centre

Remote sensing and data availability

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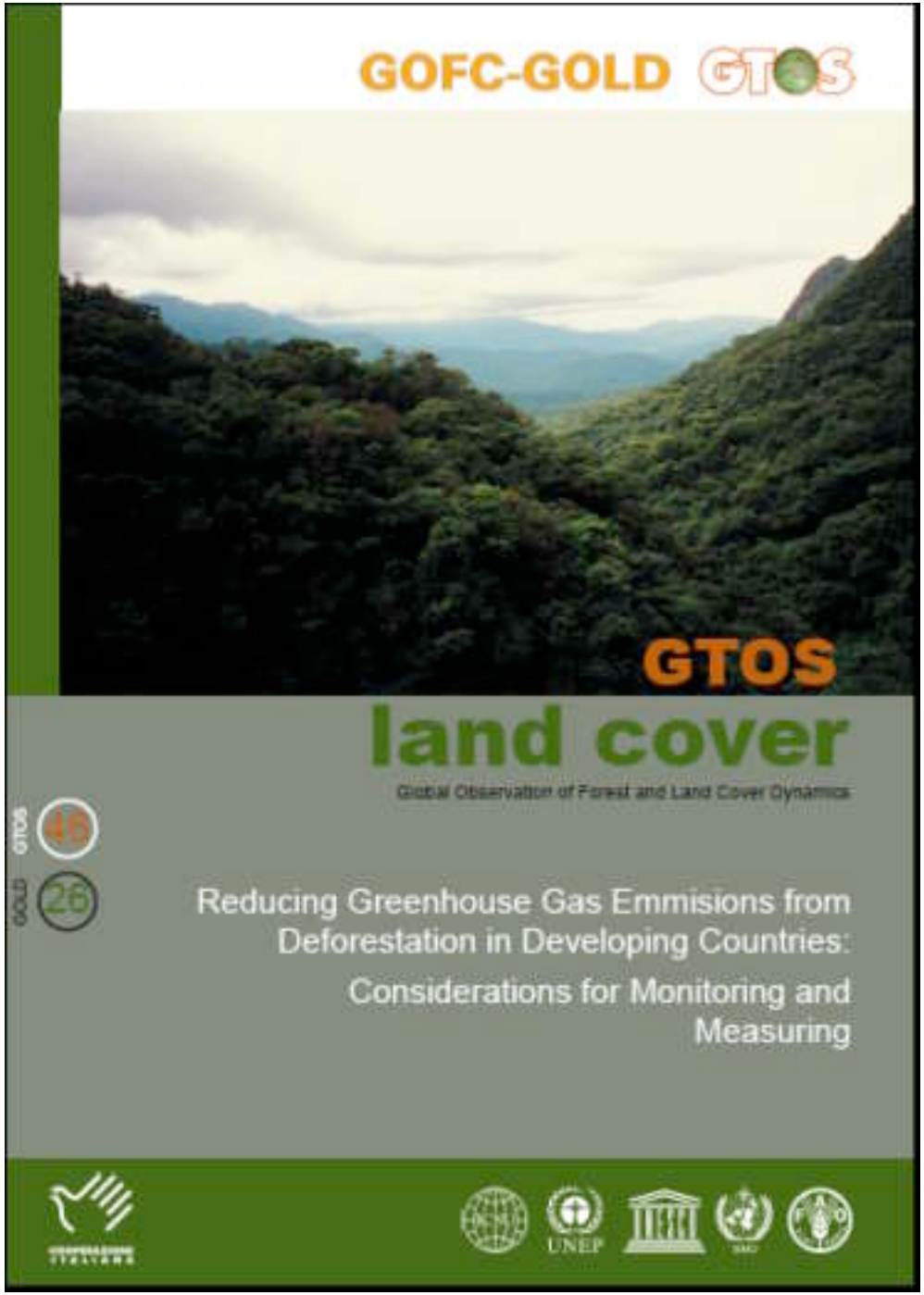
Measuring deforestation & degradation in the Tropics using Earth Observation techniques

by

Dr. Frédéric Achard

Joint Research Centre



Reference:

DeFries, Achard, Brown, Herold, Murdiyar Schlamadinger, De Souza, 2006.

Reducing GHG Emissions from Deforesta in Developing Countries: Considerations f Monitoring and Measuring.

***Report of the Global Terrestrial Observ System (GTOS) # 46, 23 p**.*

Available at: www.fao.org/gtos/pubs.html

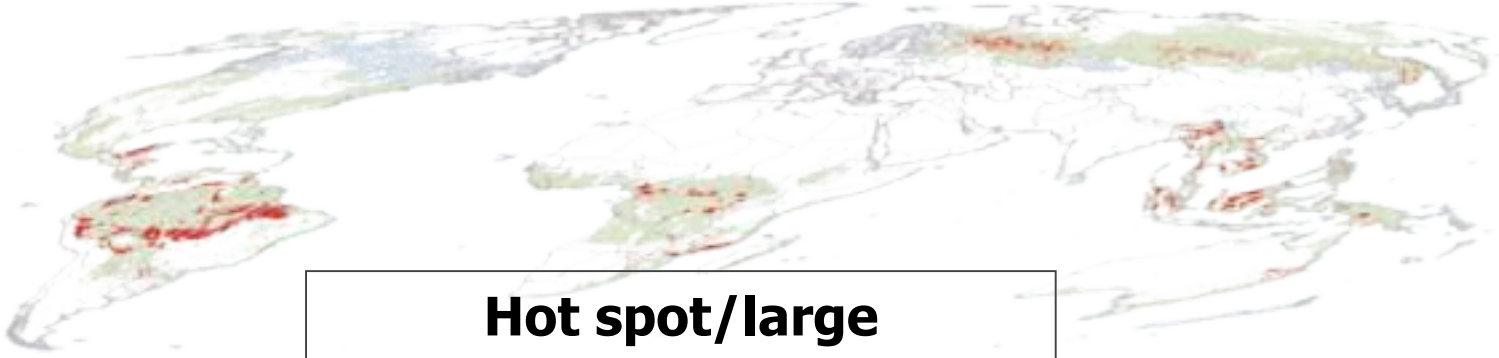
Measuring deforestation & degradation in the Tropics using Earth Observation techniques

- ***Monitoring deforested area***
  - **Can be done with confidence, variety of methods**
- ***Monitoring degraded forest area***
  - **Important but more challenging**
- ***Monitoring carbon stock changes***
  - **Already established in IPCC + use of remote sensing**

1. Selection of data and methods
    - Medium resolution (250m - 1km) for annual monitoring of large events
    - High resolution (10m - 60m) for change estimates over 5-10 years
    - Very high resolution (1 m – 5 m) for verification on limited areas

2. Examples of monitoring system at national to regional / global scales
    - Brazilian / Indian surveys
    - JRC / FAO remote sensing surveys

Global observation

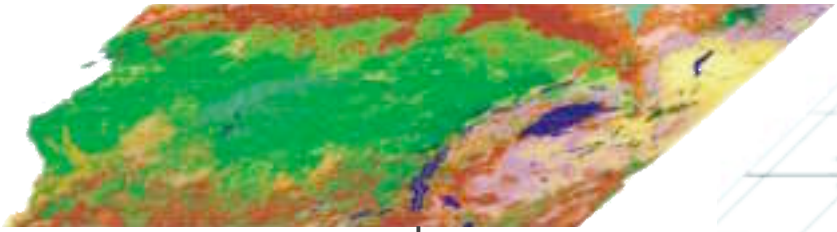


MODIS-type sensors
Deforestation (~10-20 ha)
(intra-) annual
Hot spots of forest change

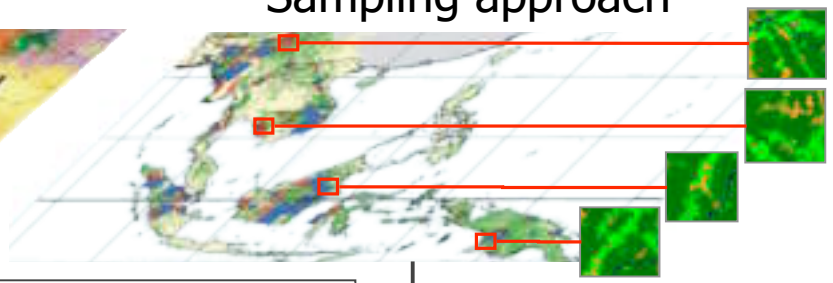
Hot spot/large deforestation detection

National/local observati

Wall-to-wall mapping



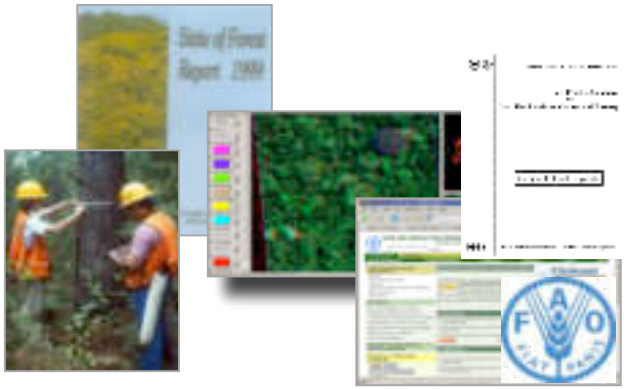
Sampling approach



Landsat-type sensors
Deforestation (~0.5-1 ha)
inter- annual (5 – 10 years)
Regionally-tuned forest degradation mapping

Change in forest area and density

Fine-scale/in-situ observation

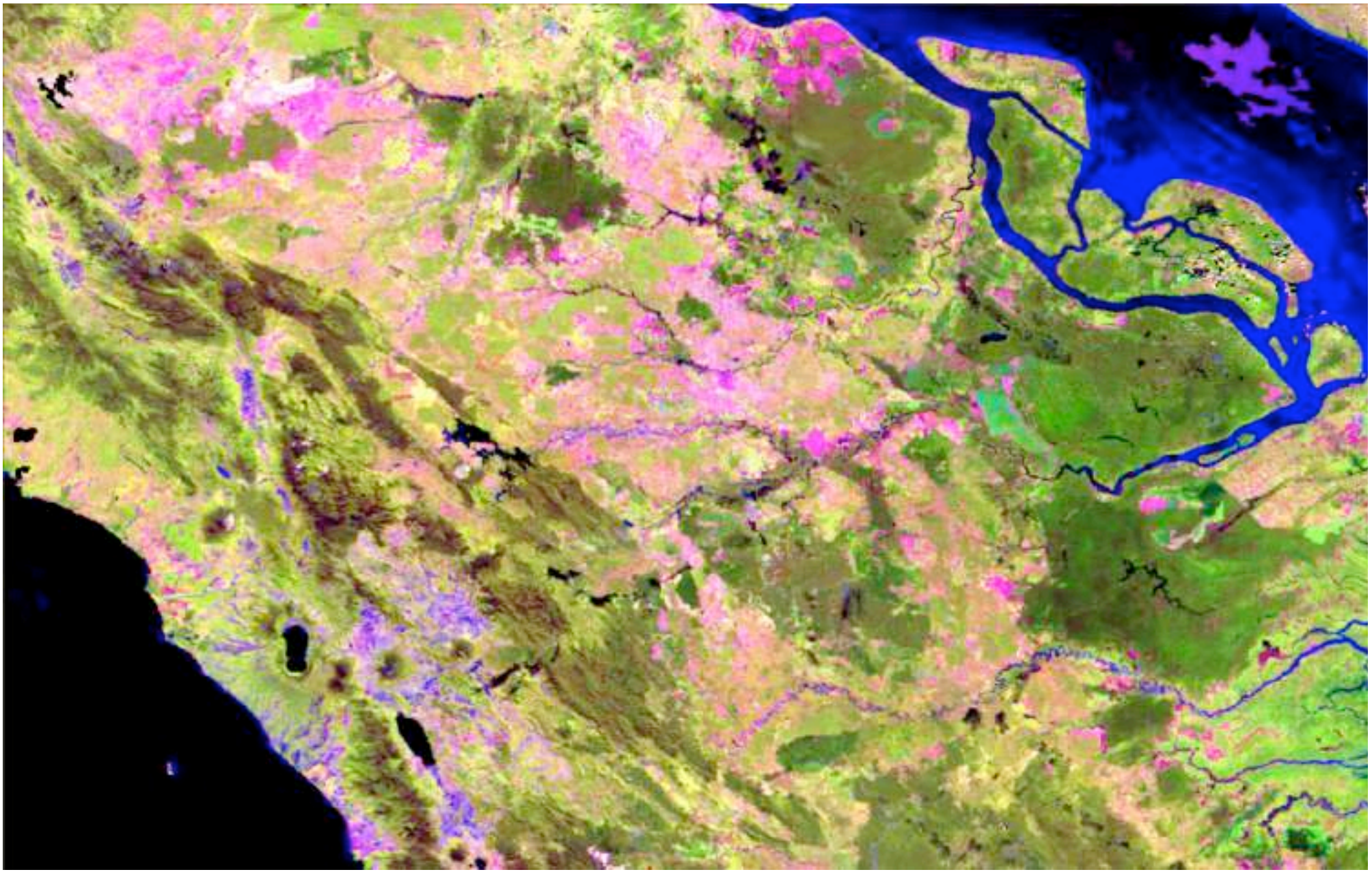


Estimation of carbon emissions

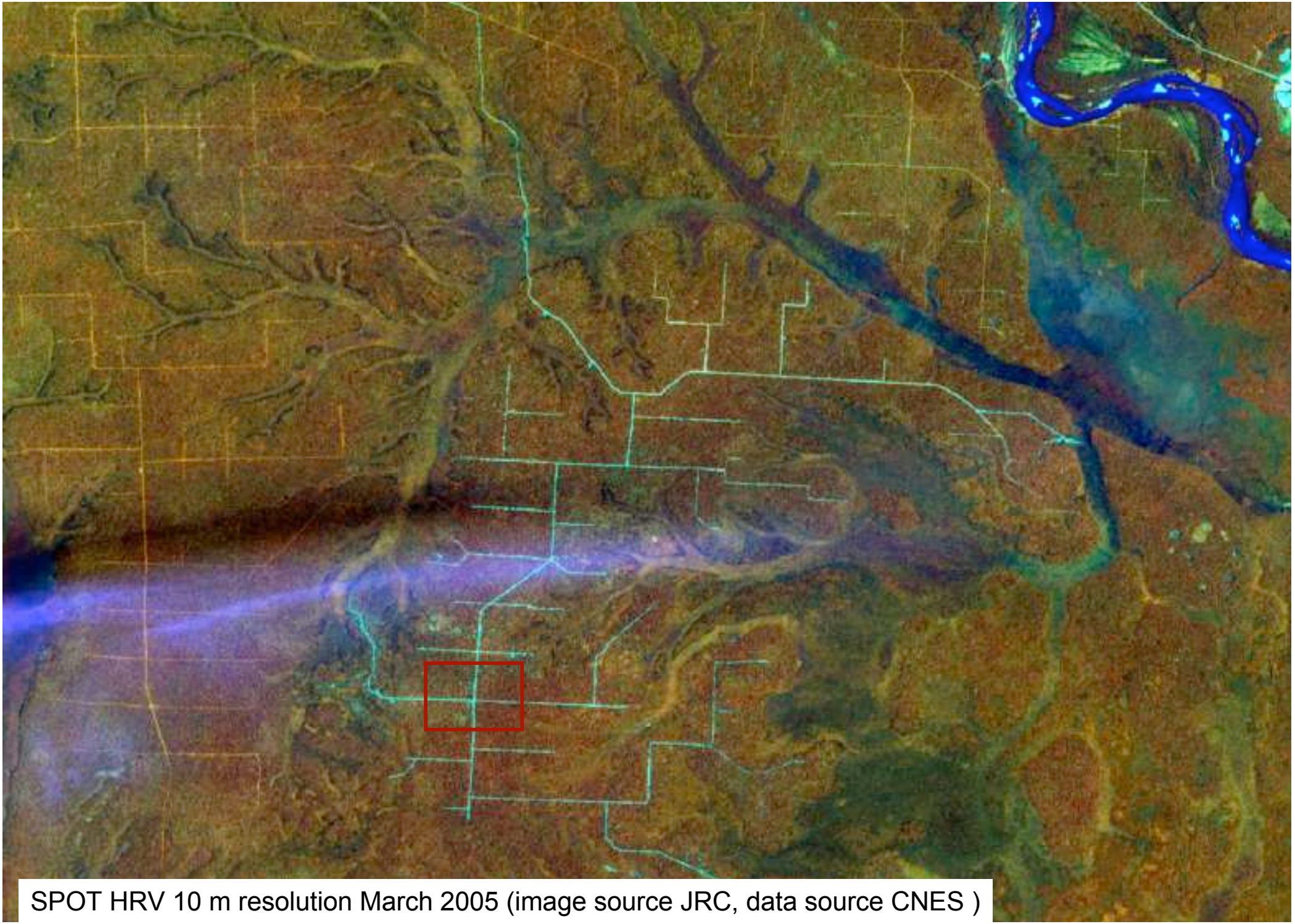
Nat./Reg. forest inventorie
In-situ/plot data
Targeted remote surveys
IPCC-LULUCF / AFOLU

GOFC-GOLD

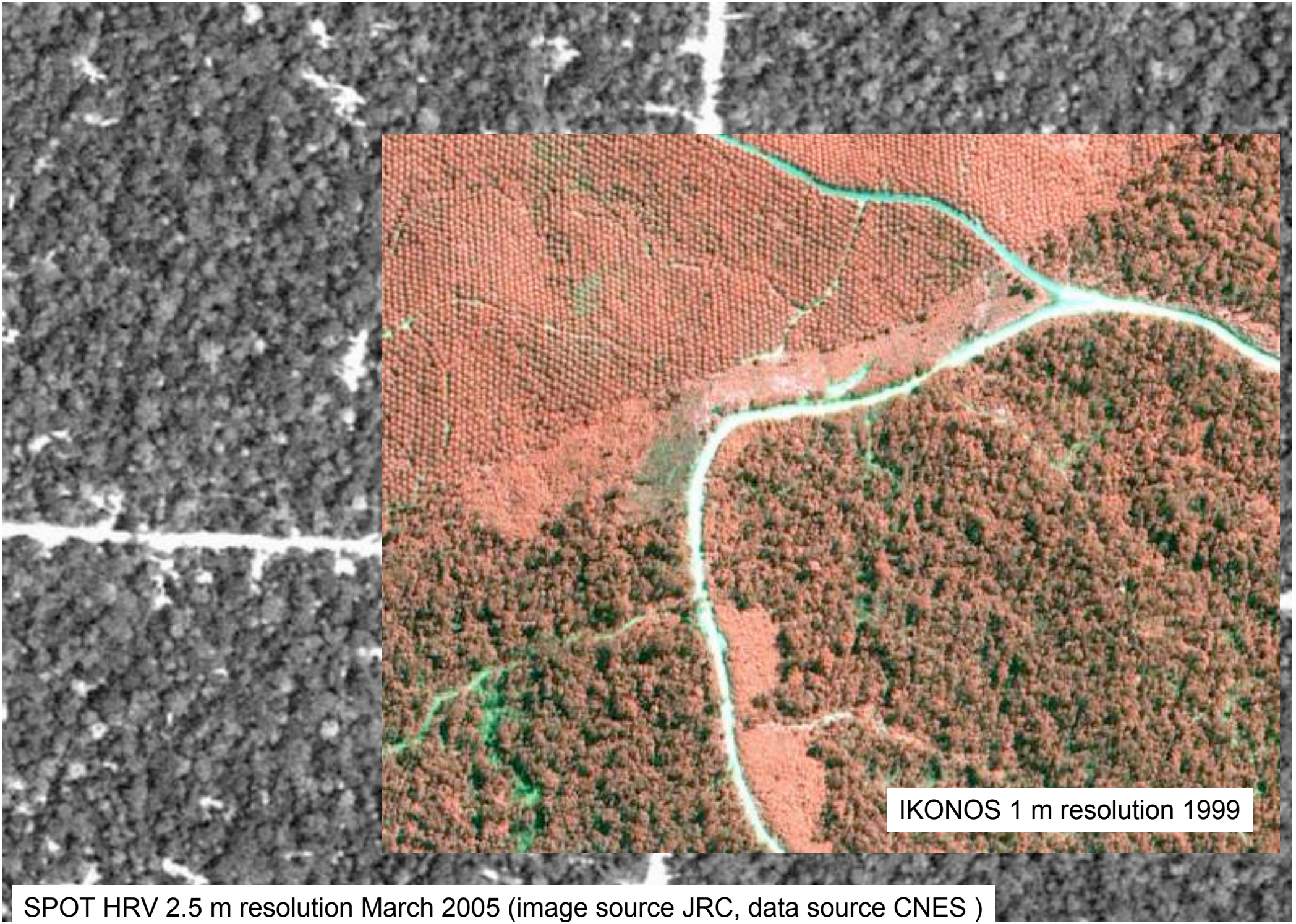
Global observations for regional forest mapping
Sumatra : SPOT-VGT (1km) in 2000 versus MODIS (250m) in 2004



Deforestation due to agricultural intensification in Rondonia between 1990 and 1997



SPOT HRV 10 m resolution March 2005 (image source JRC, data source CNES)


IKONOS 1 m resolution 1999
SPOT HRV 2.5 m resolution March 2005 (image source JRC, data source CNES)

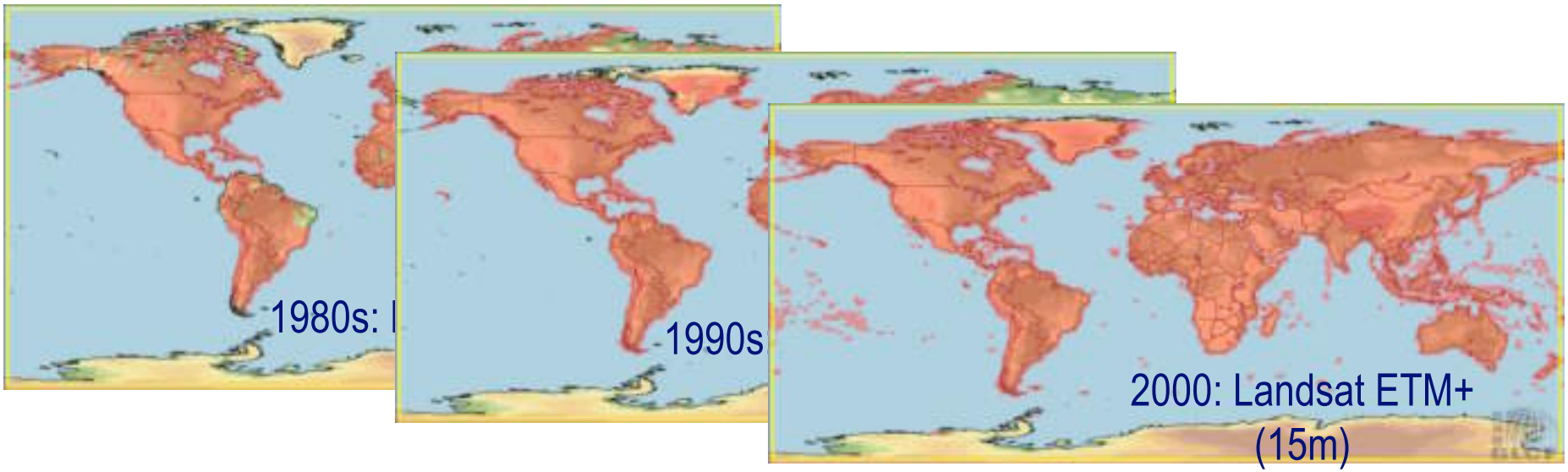
Cost of current satellite imagery

Sensor resolution	**Current sensors**	**Utility for monitoring**	**Cost**	**Cost for PNG** ***450,000 km²***
Medium (250m - 1km)	MODIS, SPOT-VGT, MERIS	Monitoring of large clearings / "hotspots"	Low or free	
High (**10 - 60m**)	**Landsat-TM, ASTER**, SPOT-HRV, AWiFs, DMC, CBERS	**Primary tool to identify /measure deforestation**	For recent: **0.02 €/km²** Low or free for historical	**Country: > 10,000 € Sample: > 3,000 €**
Very high (< 5m)	SPOT (2.5m), IKONOS, QuickBird	Validation over small areas	For recent: **2 to 33 €/km²**	**Country: 1 - 15 M€ Sample: ~ 250,000 €**

Availability of high resolution satellite imagery

1. Historical datasets: free Global Landsat coverage for 1980s, 1990s and 2000

- Global Landsat mosaics produced from NASA
  - **around-years 1990 and 2000**
  - **in production for 2005/2006**
  - available at: https://zulu.ssc.nasa.gov/mrsid/mrsid.pl
- 27,841 images are available at Global Land Cover Facility



2. Recent data: availability is good where sufficient cloud-free periods or ‘dry season

Accuracy of change estimates

from high resolution satellite imagery

“ **Accuracies of 80 to 95 %** are achievable for monitoring with high resolution imagery **to discriminate between forest and non-forest**. “

“ **Accuracies can be assessed through** in-situ observations or **analysis of very high resolution** aircraft or **satellite data**. In both cases, **a statistically valid sampling procedure** (Strahler *et al.* 2006) **can be used to determine accuracy**.

Accuracies are higher in the evergreen forest domain than in the dry forest domain.

Accuracies are higher for deforestation than for degradation.

The only **regional study on selective logging** (Asner et al, *Science*, 2005) led to **uncertainty of 14% in total logging area in Brazilian Amazon**.

Monitoring deforested area at national to global scales

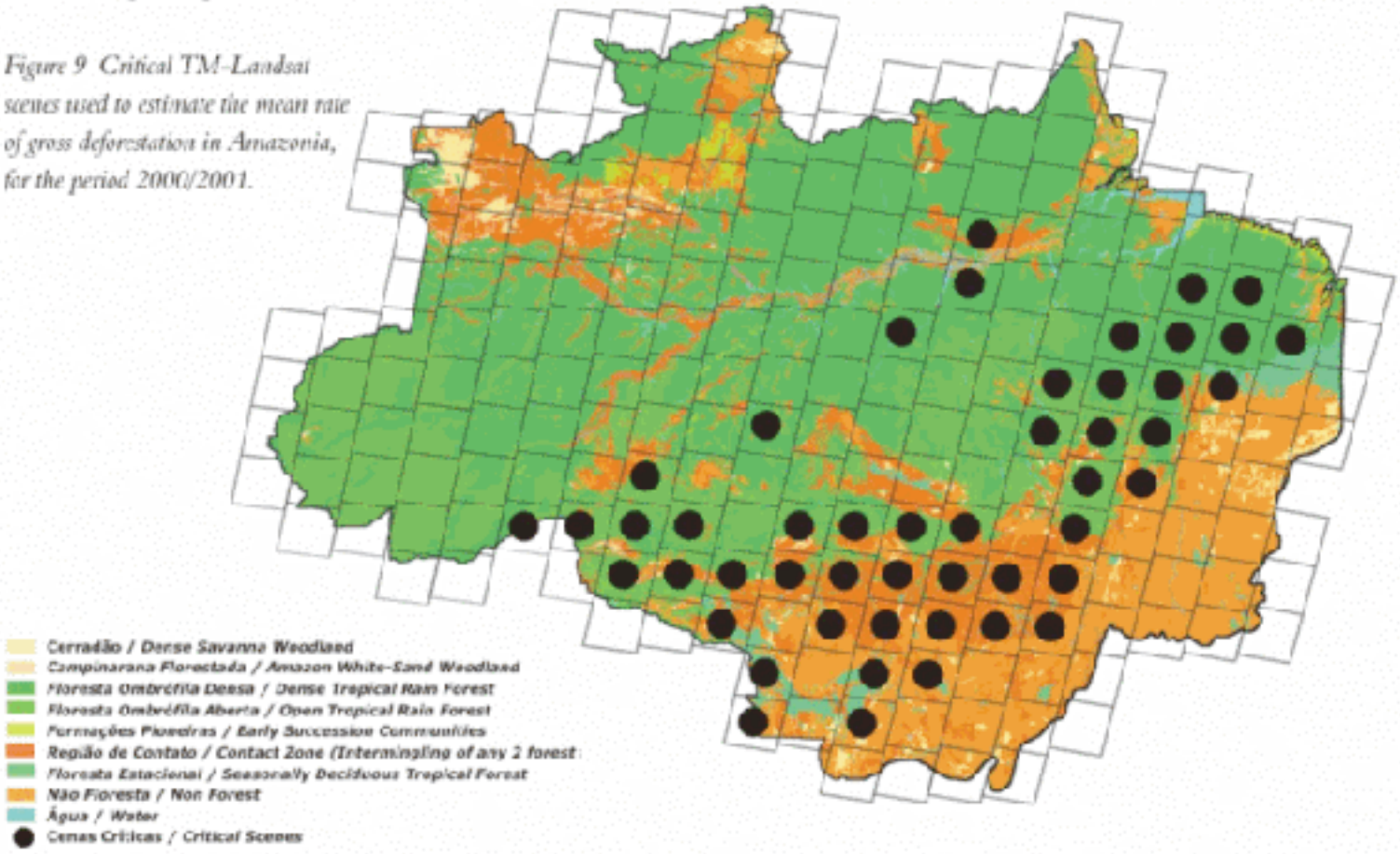
1. Selection of data and methods

2. **Examples of monitoring system at national to global scales**
   - **Brazilian / Indian surveys**
     - **Wall to wall**
     - **Yearly / 2-years period**
   - **JRC / FAO remote sensing surveys**
     - **10-years periods**
     - **Sample based (10% - 6%)**

The wall-to-wall operational system of INPE over Brazilian Amazonia

Figura 9 Cenas TM Landsat críticas consideradas na geração da estimativa da taxa média de desflorestamento bruto na Amazônia, para o período 2000/2001.

Figure 9 Critical TM-Landsat scenes used to estimate the mean rate of gross deforestation in Amazonia, for the period 2000/2001.



Ref: INPE, Mapeamento do Desmatamento da Amazônia com Imagens de Satélite, 2003

Deforestation estimates for Brazilian Amazonia

Tabela 2 - Taxa média do desflorestamento bruto (km²/ ano) de 1988 a 2000.

Table 2 - Mean rate of gross deforestation (km² / year) from 1988 to 2000.

Estados da Amazônia *Amazon States*	77/88**	88/89	89/90	90/91	91/92	92/94*	94/95	95/96	96/97	97/98	98/99	99/00
ACRE	620	540	550	380	400	482	1208	433	358	536	441	547
AMAPÁ	60	130	250	410	36	-	9	-	18	30	-	-
AMAZONAS	1510	1180	520	980	799	370	2114	1023	589	670	720	612
MARANHÃO	2450	1420	1100	670	1135	372	1745	1061	409	1012	1230	1065
MATO GROSSO	5140	5960	4020	2840	4674	6220	10391	6543	5271	6466	6963	6369
PARÁ	6990	5750	4890	3780	3787	4284	7845	6135	4139	5829	5111	6671
RONDÔNIA	2340	1430	1670	1110	2265	2595	4730	2432	1986	2041	2358	2465
RORAIMA	290	630	150	420	281	240	220	214	184	223	220	253
TOCANTINS	1650	730	580	440	409	333	797	320	273	576	216	244
AMAZÔNIA	21130	17860	13810	11130	13786	14896	29059	18161	13227	17383	17259	18226

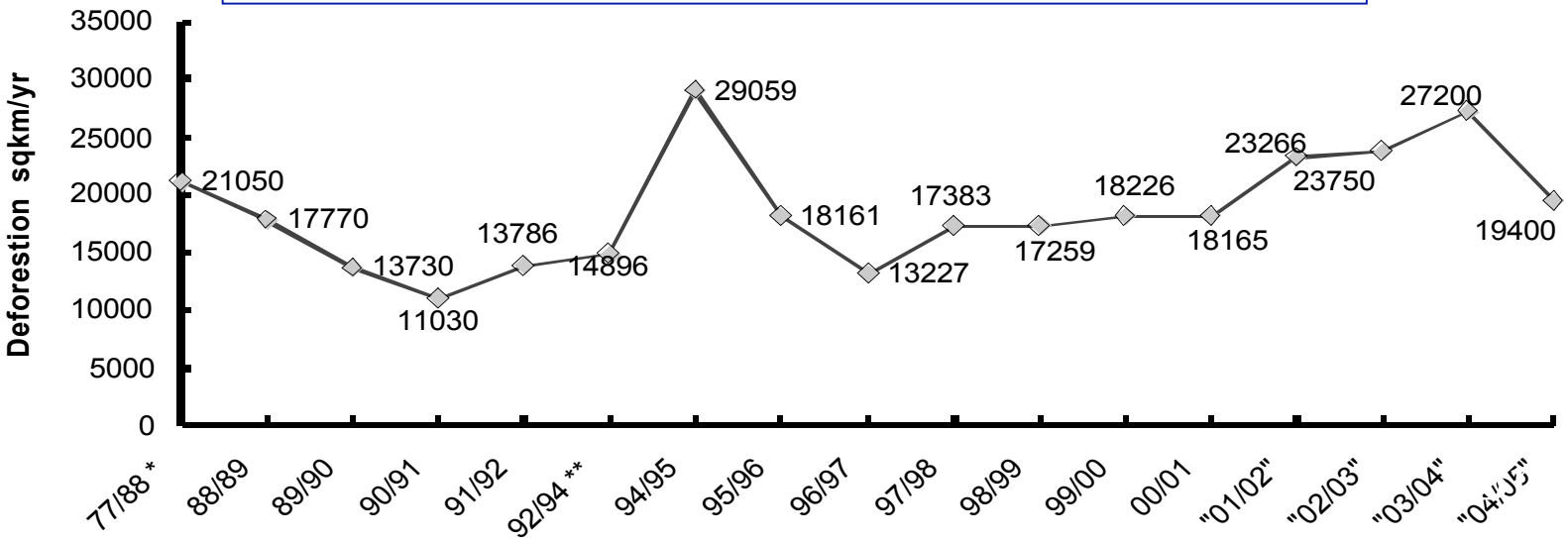
* Média da Década / *Decade Mean*

** Média do Biênio / *Biennium Mean*

Refs: INPE, Monitoring of the Brazilian Amazonian Forest by Satellite, 2002

Results at national level: Brazilian and Indian examples

Annual deforestation rates for the Brazilian Amazon

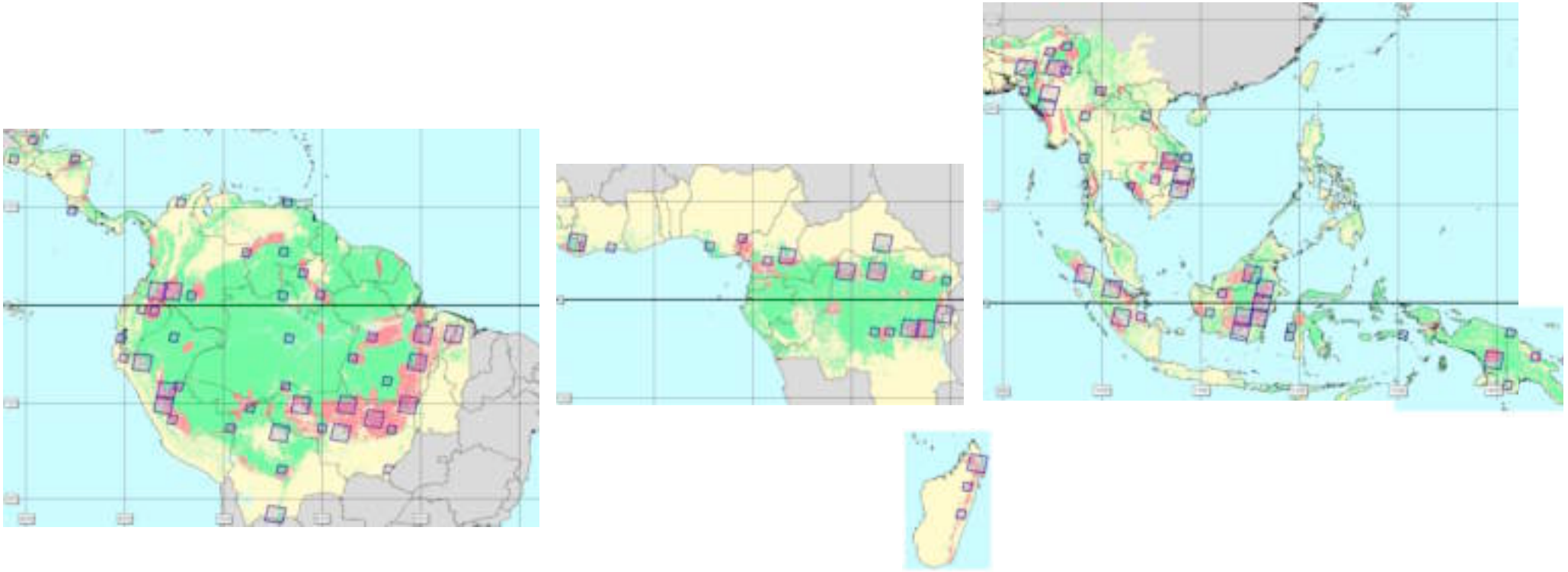


Forest assessments completed by the Forest Service of India

Cycle	Year of assessment	Satellite and sensor	Spatial resolution	Mapping scale
I	1987	Landsat MSS	80 m x 80 m	1:1 million
II	1989	Landsat TM	30 m x 30 m	1:250.000
III	1991			
IV	1993			
V	1995	IRS-1B / LISS-II	36 m x 36 m	
VI	1997			
VII	1999	IRS-1C / LISS-III	23 m x 23 m	
VIII	2001	IRS-1C/1D / LISS-III	23 m x 23 m	1:50.000
IX	2003	IRS-1D / LISS-III	23 m x 23 m	1:50.000

FAO FRA 1990-2000 pan-tropical remote sensing survey

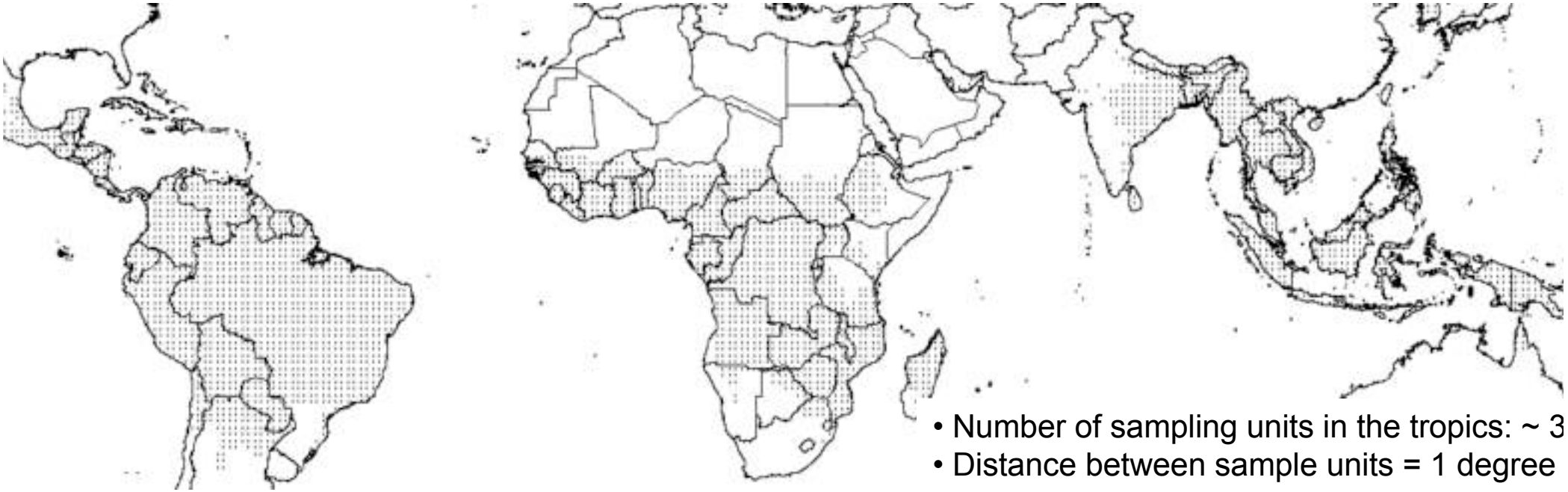
JRC TREES-II 1990-1997 remote sensing survey



Comparison of estimates of net change at pan-tropical level

	Humid domain		All Tropics		
Continent	FAO Country	JRC TREES	FAO Country	FAO RS Survey	NASA AVHRR
South East Asia	-2.5	**-2.0 ±0.8**	-2.4	**-2.0 ±1.2**	**-2.0 ±1.2**
Africa	-1.2	-0.7 ±0.3	-5.2	-2.2 ±0.8	-0.4 ±0.3
Latin America	-2.7	-2.2 ±1.2	-4.4	-4.1 ±2.2	-3.2 ±1.2
Global	-6.4	-4.9 ±1.3	-12.0	-8.3 ±2.6	-5.6 ±2.7

Options for future monitoring : Systematic sampling



- Number of sampling units in the tropics: ~ 3
- Distance between sample units = 1 degree

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Tropical forest cover change in the 1990s and options for future monitoring

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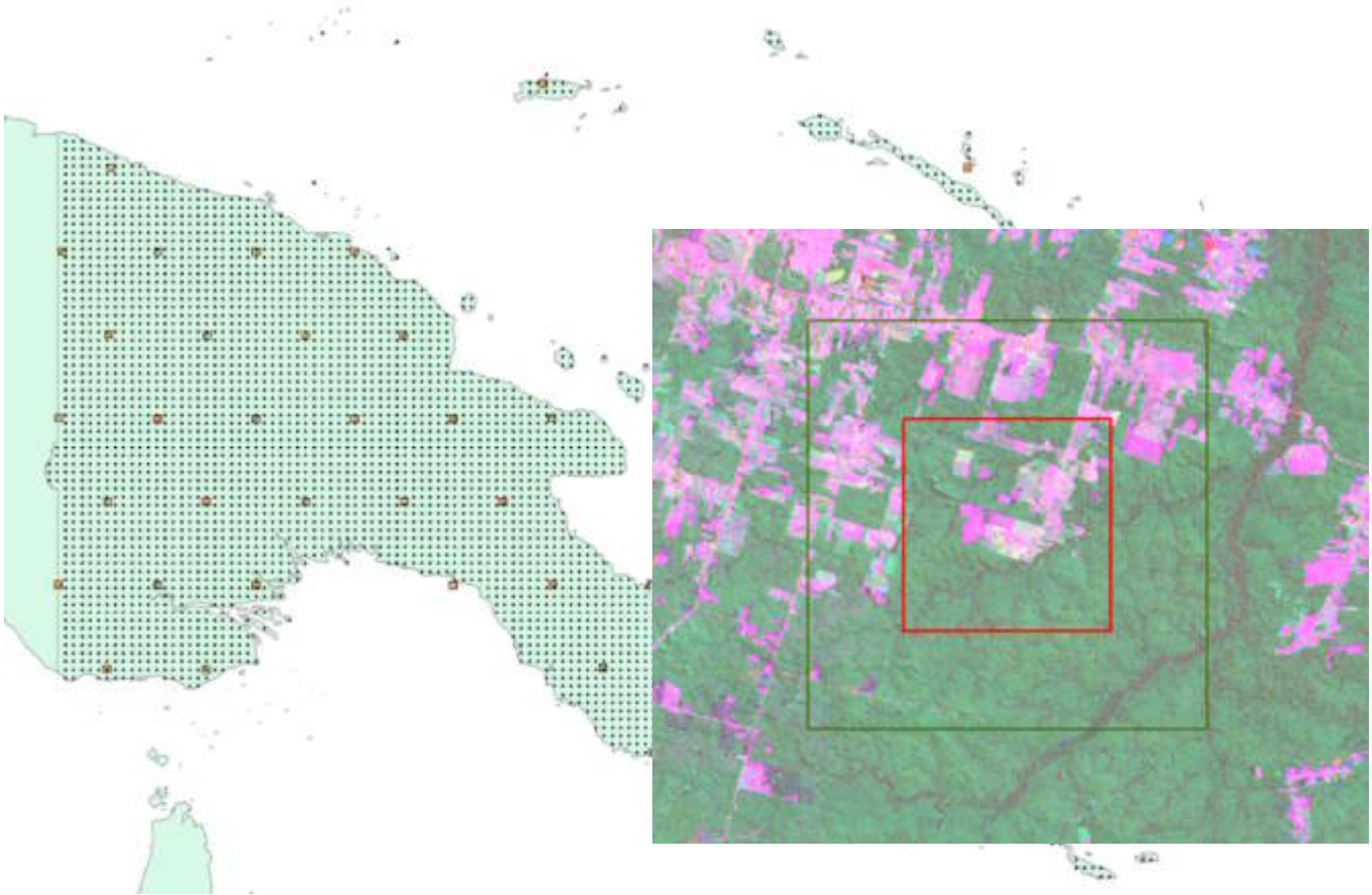
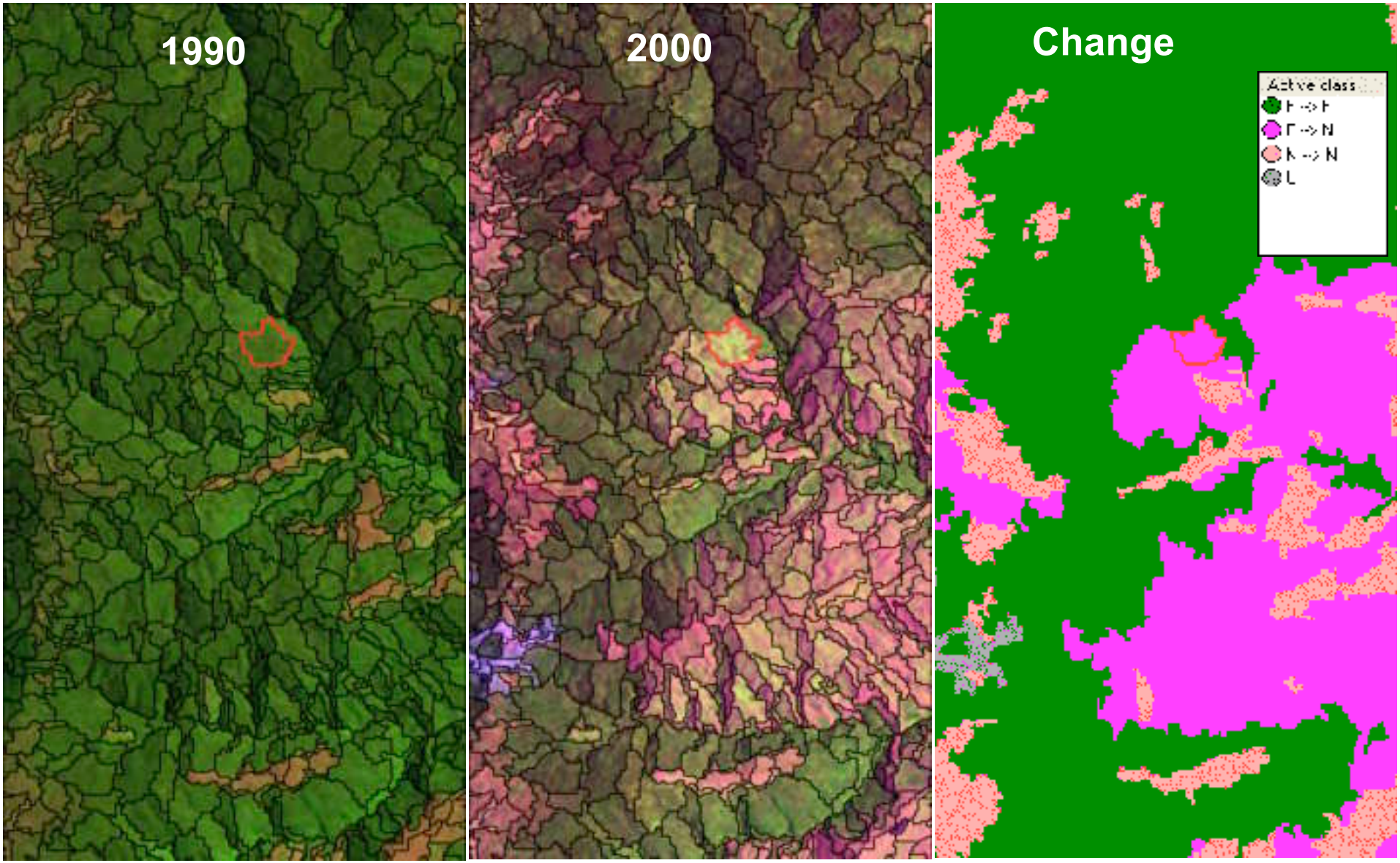
[2]*FORM—Forest Resources Development Service—Food and Agriculture Organization of the*

Systematic sample based on geographical lat-long grid



Automated change assessment methods



Conclusions

1. Choice of methods

"Various methods are available and appropriate to analyze satellite data for measuring changes in forest area"

2. Satellite data availability

"Key constraints in implementing national systems for monitoring changes in forest area are cost and access to high resolution data"

Summary of advantages

1. Based on routine technology
   - JRC TREES : pan-tropical deforestation estimates
   - INPE Brazil : national forest monitoring
   - FAO FRA : global forest resource assessment

2. Spatially and temporally explicit information allowing:
   Quantitative estimates including precise location of boundary and area
   Local field control
   Integration into regional statistics

3. Source data are often free & online
   (when field control of large areas costly)
   Most the data are publicly available & visible

4. Traceable and open to scrutiny
   Documented
   Based on objective independent source data
   Repeatable