



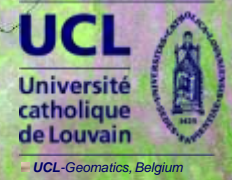
COMIFAC - Atelier régional

Suivi des stocks et flux de carbone dans le Bassin du Congo

Février 2010 - Brazzaville

Observatory of Central African Forests : National and regional estimate of forest cover and forest cover change for 1990, 2000 and 2005

C. Ernst, A. Verhegghen, C. Bodart, P. Mayaux, C. de Wasseige,
A. Bararwandika, G. Begoto, F. Esono Mba, M. Ibara, A. Kondjo
Shoko, H. Koy Kondjo, J-S. Makak, J-D. Menomo Biang, C. Musampa,
R. Ncogo Motogo, G. Neba Shu, B. Nkoumakali, C-B. Ouissika and
P. Defourny



with the contribution of national institutions, SDSU and FAO-FRA

DIAF/MECNT
RDCongo





Guinée Cameroun
Eq. CONGO RCA





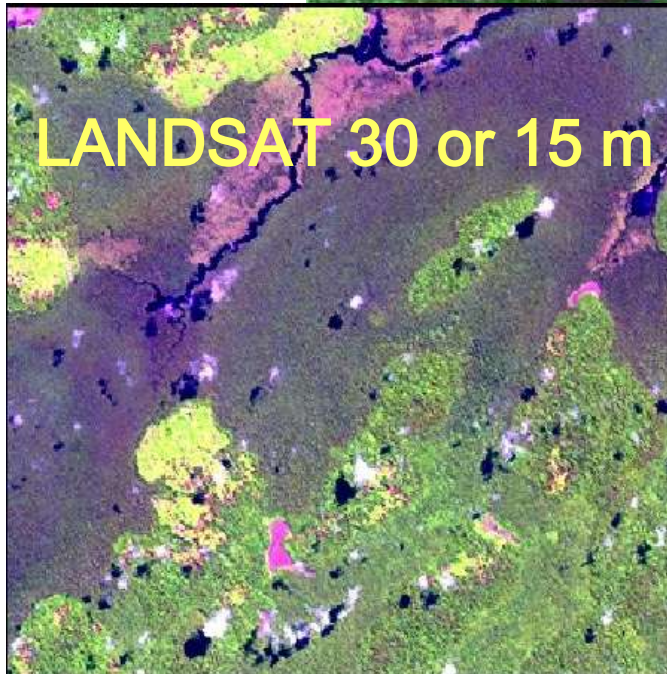
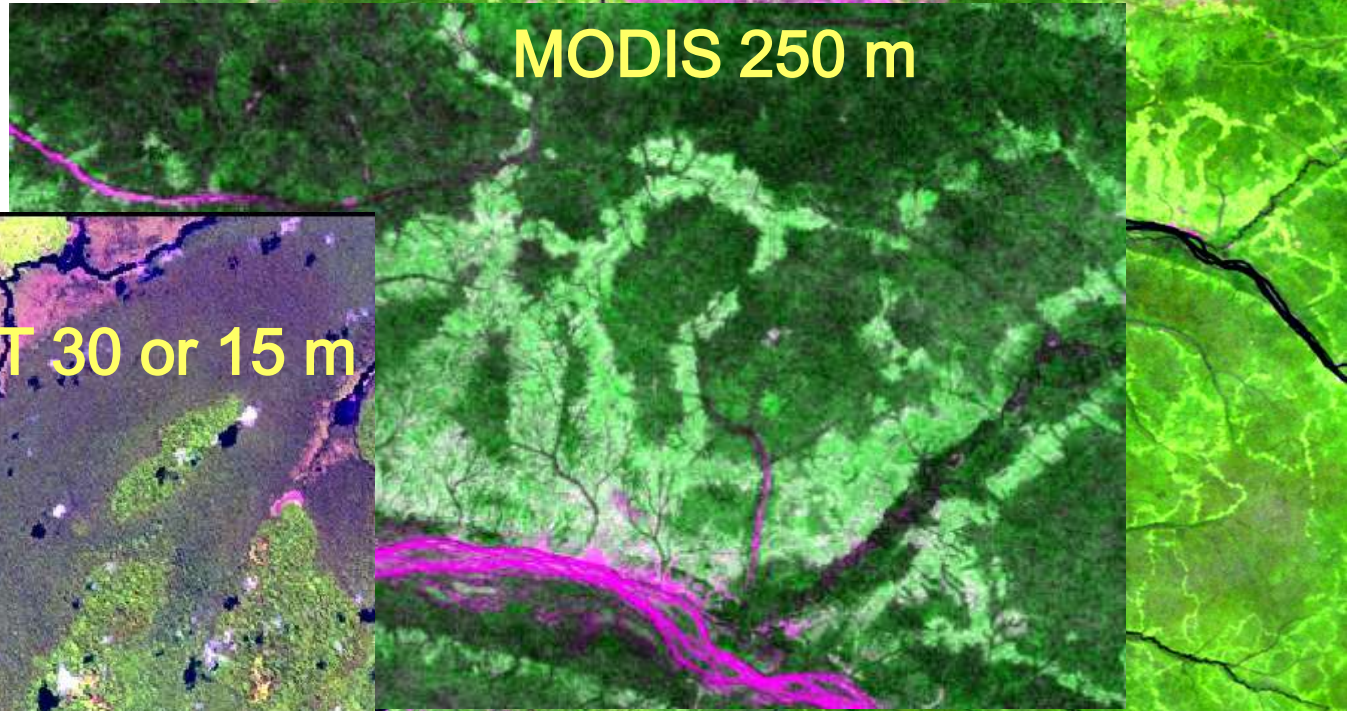
Critical information needs

- 
Reliable and **up-to-date info** for governments to define and monitor forest policies
 (Plan de convergence – CBFP framework)

- 
Objective and **verifiable** according to **int. standards** for the international community to report to international conventions
 (UNFCCC, Biodiversity Convention, REDD Initiative, ...)



Adequate Earth Observation technologies





Maturity of optical EO approaches



Maturity of scientific methods for

- standard processing of satellite observation
- forest types definition (FAO-LCCS)
- forest types mapping
- forest cover change detection (GOFC-GOLD)



High speed computing capabilities for

- large volume data acquisition and management
- mass volume processing in a repeatable way



OFAC - an efficient Partnership

- Administrations and national experts
- Regional technical office (EU-FORAF)
- International scientific community
 - EU-Joint Research Center (JRC)
 - University of Maryland (UMd-Carpe)
 - South Dakota State University (SDSU)
 - Université catholique de Louvain (UCL)
- FAO-Forest Resources Assessment 2010



⇒ **for a collaborative and consolidated forest assessment** (SOF 2006, 2008 and... 2010)



Operational results: basin-wide forest type map at 300 m

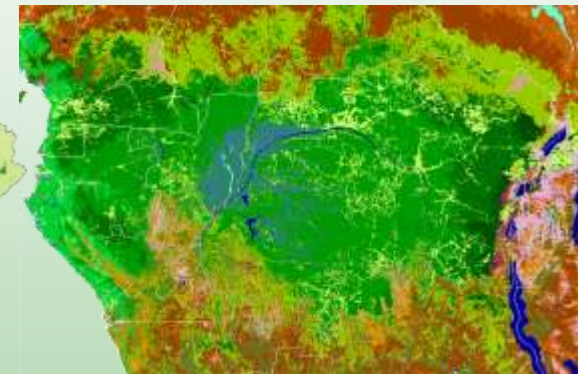
collaborative
synthesis



From MERIS 2005-2006 data
SPOT VEGETATION 2000-2008 data



From Landsat and
MODIS 2000-2007 data



JRC
EUROPEAN COMMISSION

From SPOT VEGETATION 2000 data



Operational results: basin-wide forest type map at 300 m

Vegetation Map

- Lowland rain Forest
- Semi-mountain Forest
- Mountain Forest
- Swamp Forest
- Mangrove
- Rural Complex
- Forest-Savanna Mosaic
- Miombo Woodland
- Woodland and Tree Savanna
- Shrubland
- Grassland
- Other Vegetation

Roads

- Primary paved roads
- Primary roads (permanent or random practicability)
- Secondary paved roads (permanent or random practicability)
- Secondary roads (intermittente practicability)

Cities

- COUNTRY CAPITAL
- over 500.000
- 500.000 - 200.000
- 200.000 - 50.000



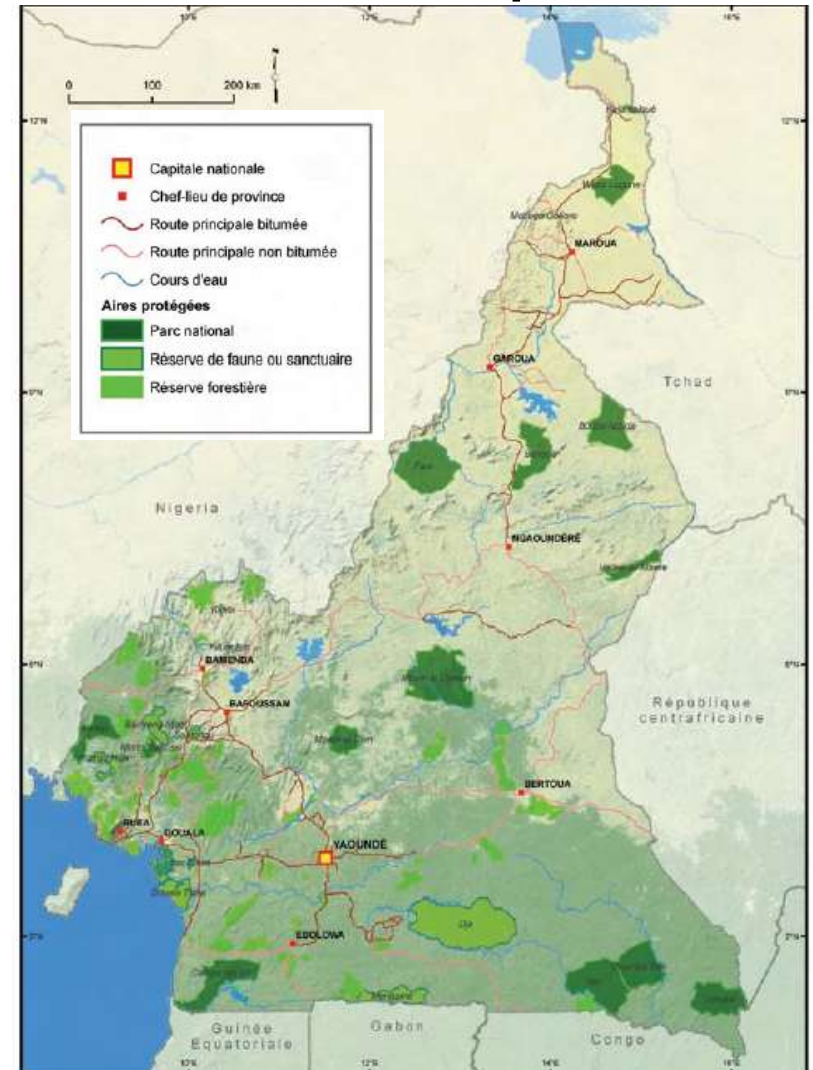


Operational results: basin-wide forest types area estimate

Land cover class	Area (km ²)	% Sub Region
Closed evergreen lowland forest	1.421.834	35
Submontane forest (900-1500m)	63.100	2
Montane forest (> 1500 m)	9.754	0
Swamp forest	123.264	3
Mangrove	1.926	0
Total humid forest	1.619.879	40
Mosaic forest/croplands	370.123	9
Mosaic forest/Savannah	588.011	15
Closed deciduous forest	304.808	8
Deciduous woodland	630.890	16
Open deciduous shrub land, sparse trees	301.220	7
Others	233.540	6
TOTAL Sub region (Congo Basin)	4.048.470	100

in *State of the Forest 2008 (COMIFAC,2009)*

Operational results: national land allocation maps



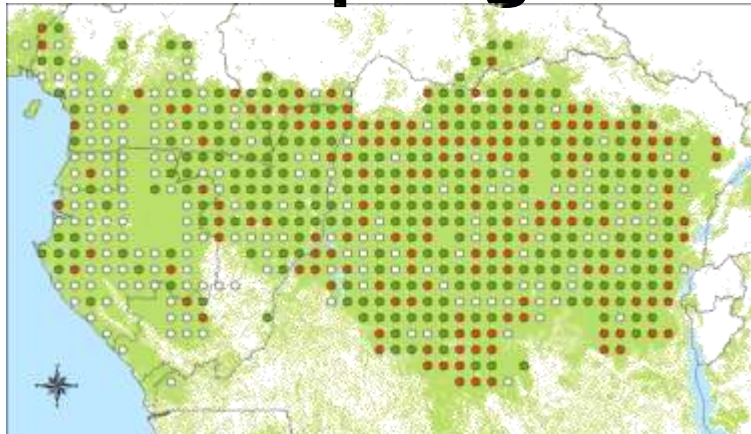
Source: WRI et FORAF

in *State of the Forest 2008 (COMIFAC, 2009)*

Operational results: forest cover change detection

forest change estimate derived from 2 distinct approaches

sampling



wall-to-wall mapping

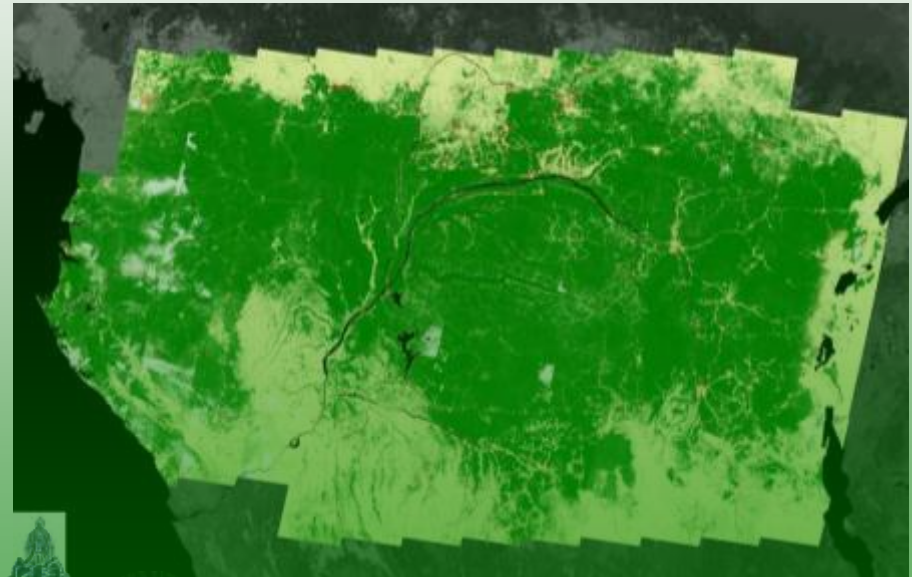
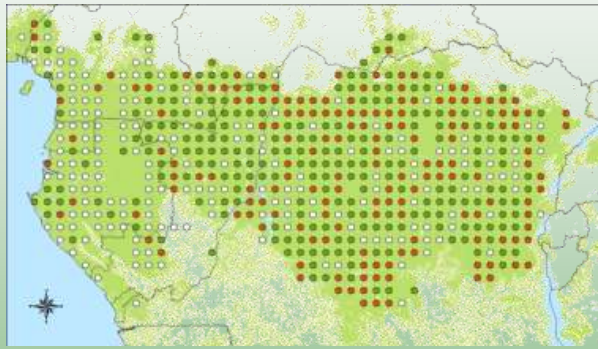


Operational results: forest cover change detection



Synthesis

for forest cover estimate 1990-2000, 2005 and ...2010



Country	n	Gross Deforestation	Gross Reforestation	Net Deforestation
Cameroon	32	0.20% ± 0.20%	0.06% ± 0.06%	0.14%
Congo-Brazzaville	51	0.07% ± 0.04%	0.05% ± 0.06%	0.02%
Gabon	21	0.12% ± 0.11%	0.03% ± 0.03%	0.09%
Eq. Guinea	2	0.31% ± 0.11%	0.00% ± 0.01%	
C. A. Republic	14	0.12% ± 0.10%	0.06% ± 0.08%	0.06%
D. R. Congo	267	0.25% ± 0.06%	0.05% ± 0.01%	0.20%
Central Africa	209	0.21% ± 0.05%	0.05% ± 0.01%	0.16%

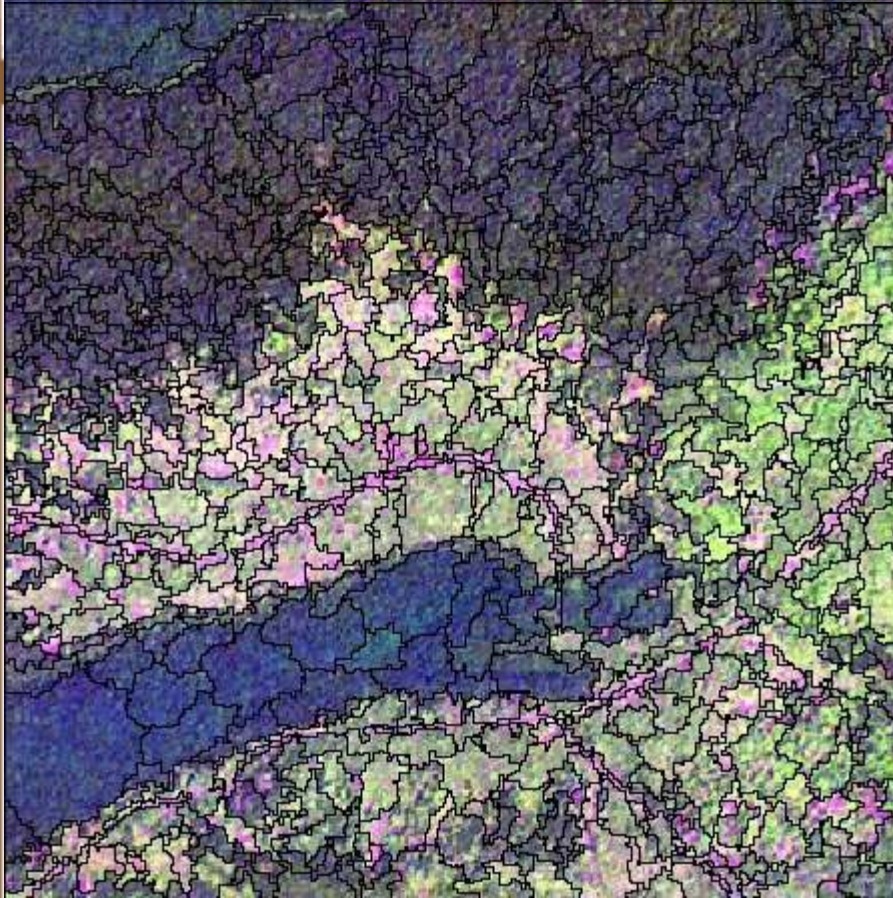


From LANDSAT 1990-2000 extracts

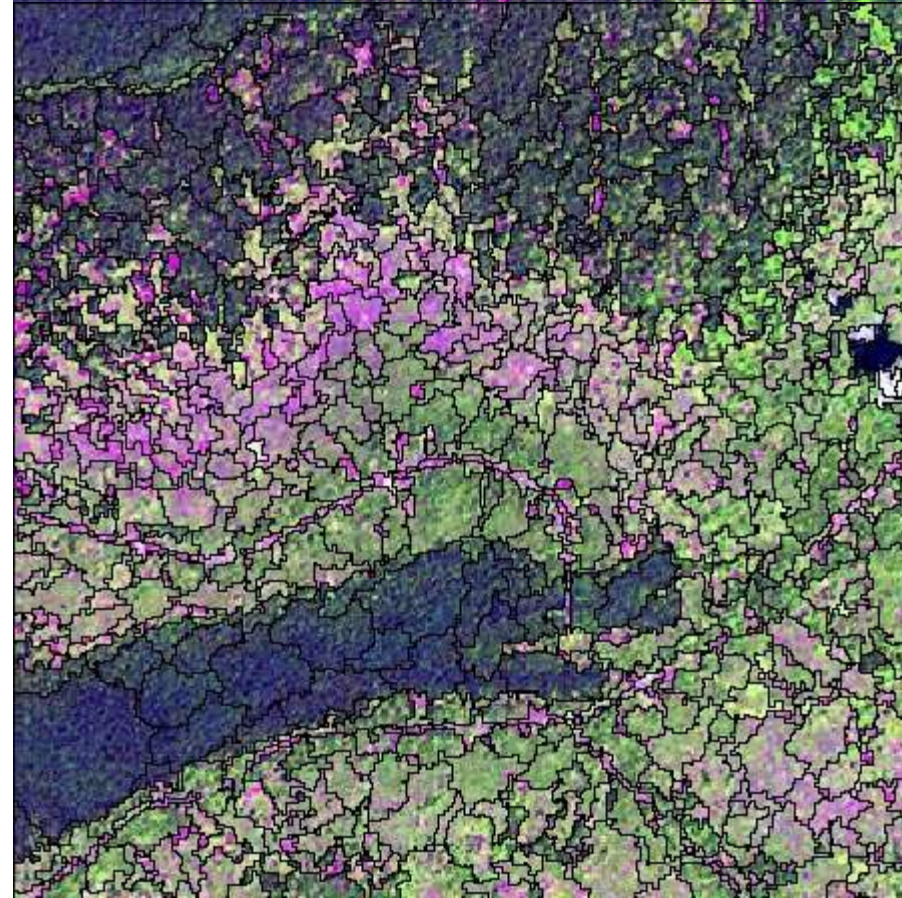
From LANDSAT 1990 – 2000 mosaics

Pilot study :

forest cover change detection



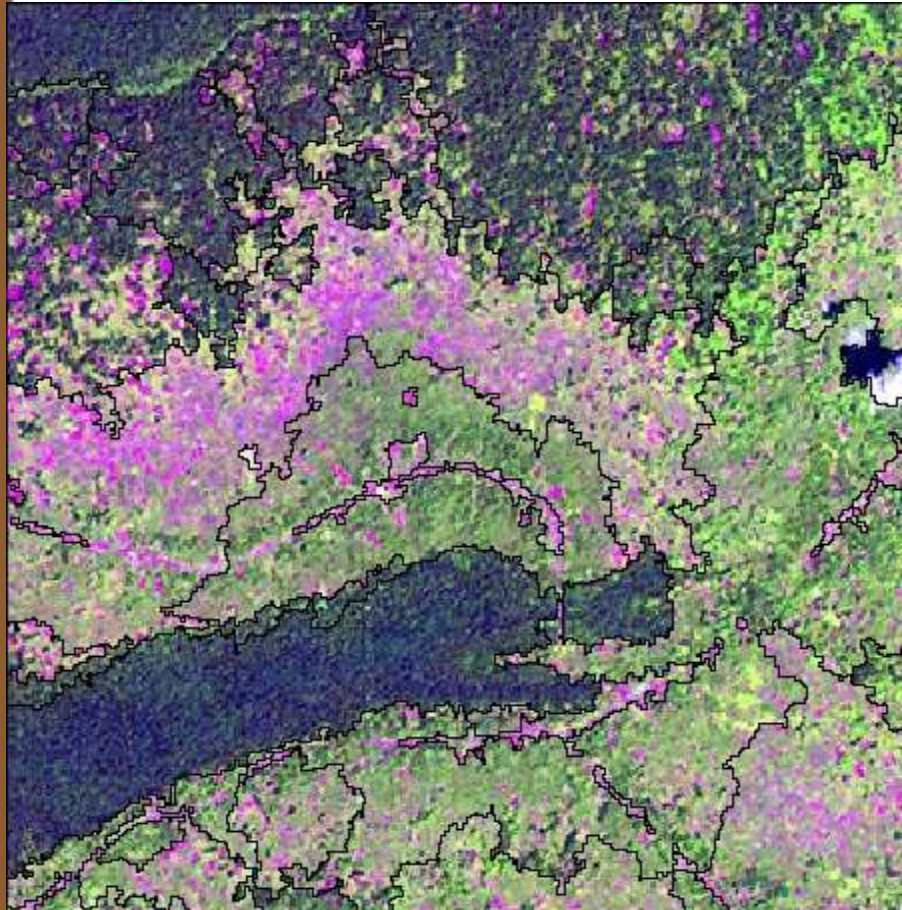
1990



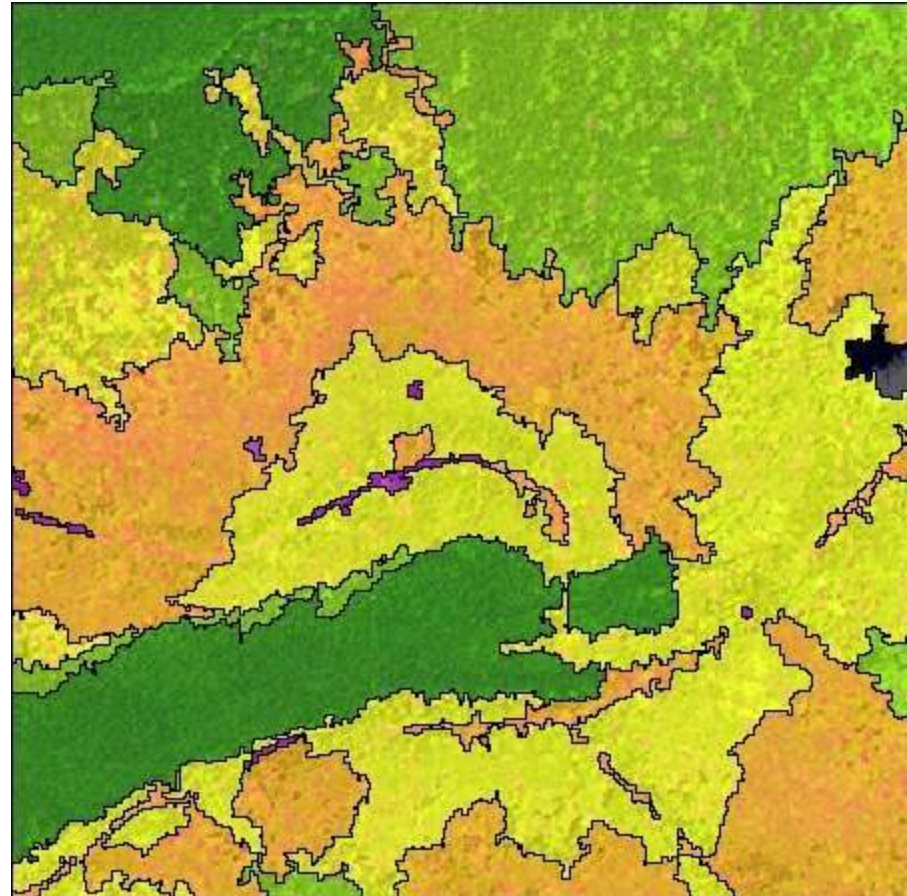
2000

Pilot study :

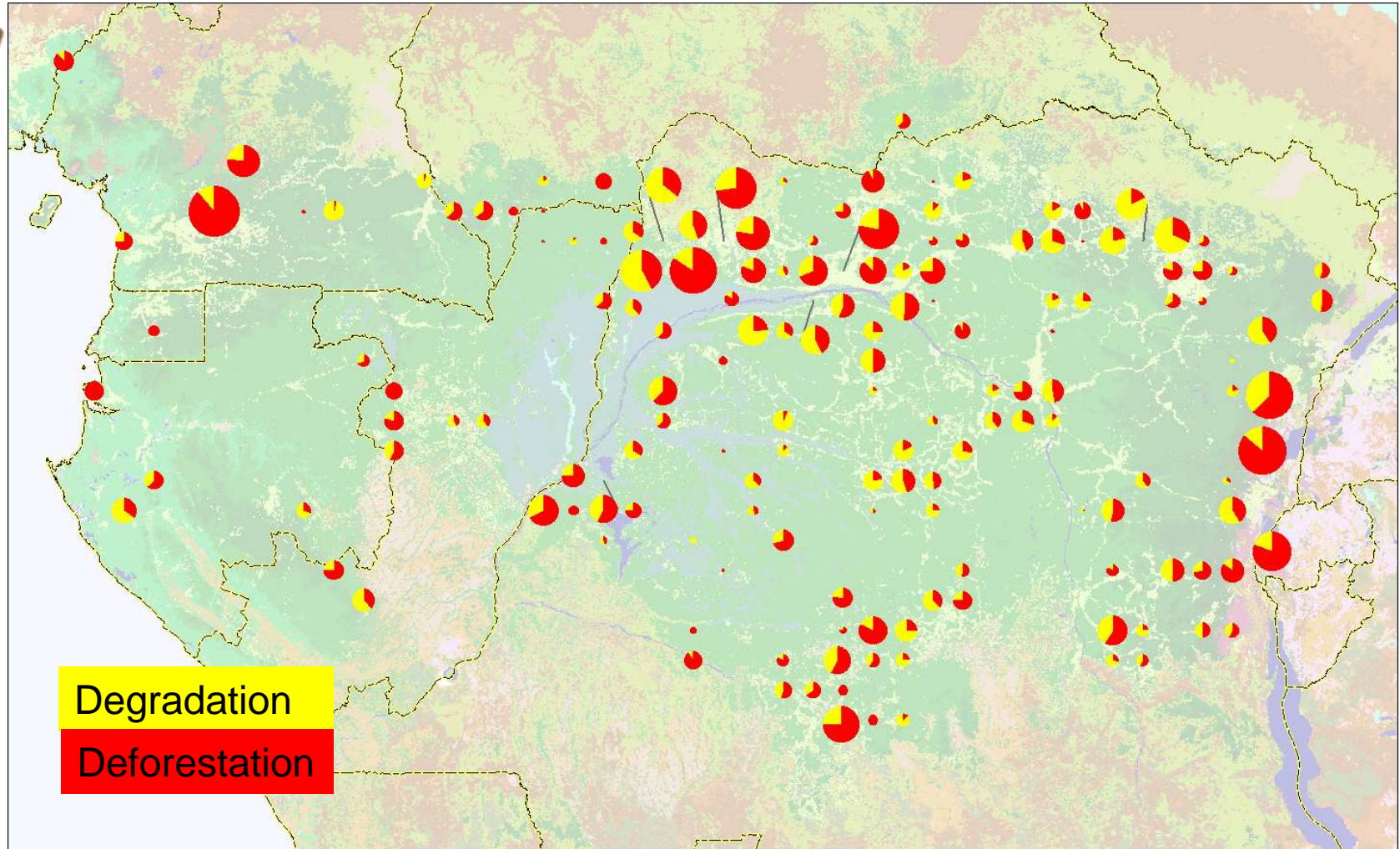
forest cover change detection



2000



Pilot results: forest cover change detection





OFAC Pilot results: forest cover change detection for 1990- 2000



Tableau 1.3 : Taux annuels de déforestation en zone de forêt dense dans les pays du bassin du Congo entre 1990 et 2000

Pays	Déforestation brute (%) (1)	Déforestation nette (%) (Duveiller et al. 2008)
RDC	0,21	0,20
Congo	0,07	0,02
RCA	0,19	0,06
Cameroun (*)	0,14	0,14
Gabon (*)	0,09	0,09
Guinée Eq. (*)	0,10	
Bassin du Congo	0,17	0,16

() du fait du faible taux d'échantillonnage dans l'étude de Duveiller et al., 2008; le chiffre de la Guinée équatoriale est issu de Hansen et al., 2008a.*

Source : (1) chiffres adaptés à partir des travaux de Duveiller et al., 2008 et Hansen et al., 2008a.

in State of the forest – 2008

(Duveiller et al., 2008 and SDSU estimate)

OFAC Pilot results:



forest cover change detection for 1990- 2000



Tableau 1.4 : Taux annuels de dégradation et de régénération en zone de forêt dense dans les pays du bassin du Congo entre 1990 et 2000

Pays	Dégradation brute (%)	Régénération brute (%)	Dégradation nette (%)
RDC	0,19	0,07	0,12
Congo	0,04	0,04	0,00
RCA	0,06	0,04	0,02
Cameroun (*)	0,07	0,06	0,01
Gabon (*)	0,09	0,01	0,08
Guinée Eq. (*)	0,00	0,32	
Bassin du Congo	0,15	0,06	0,09






() Les chiffres de ces pays sont à considérer avec prudence du fait d'un taux d'échantillonnage faible à très faible.*

Source : adapté de Duveiller et al, 2008.

from the State of the forest – 2008












A collaborative approach in the framework of OFAC

- 
Nov. 2008: Atelier régional sur l'Etat des Forêts 08
 => working group on forest cover change
- 
Feb. 2009: Pilot experience for validation by national experts
- 
Mar. 2009: Scientific and technical development by JRC (data screening, validation tool) and by UCL (automated processing chain)
- 
Sept. 2009: Validation workshop with nat. experts
- 
Feb. 2010: Feedback from data compilation
 QC data set distribution



Objectives

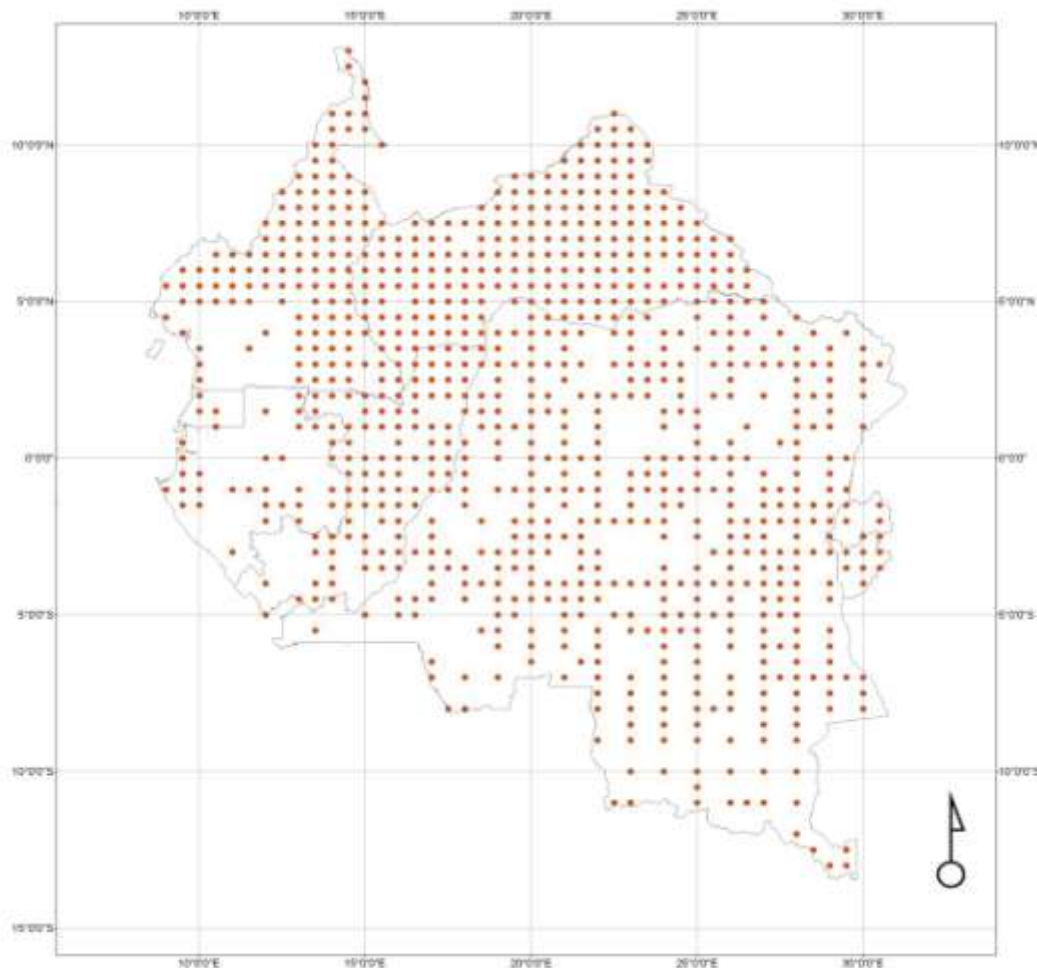
National estimate of forest cover changes

-  over two time intervals
 -  1990-2000
 -  2000-2005
-  4 forest cover change processes
 -  Degradation
 -  Regeneration
 -  Deforestation
 -  Reforestation
-  combining advanced EO methods and a **significant contribution of national experts**

Operational results:



forest cover change estimate at national level with national experts



Area Frame Sampling:

- ½ degree for all
- (¼ degree for Eq. Guinea)

=> **1168 samples** of Landsat
extracts of 20 x 20 km

Most advanced automated
approaches for
pre-processing (JRC algorithms)
pre-interpretation (UCL algorithms)

for final interactive interpretation
by national experts

(FAO Working Document 155, 2009)

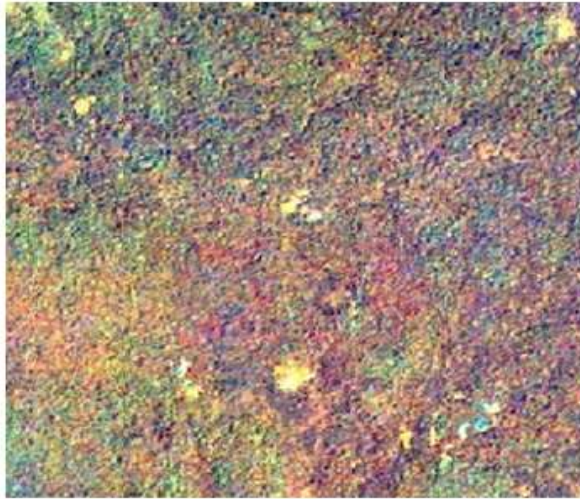
Carbon Monitoring in CB Forests – Brazzaville, 2010

Methodology

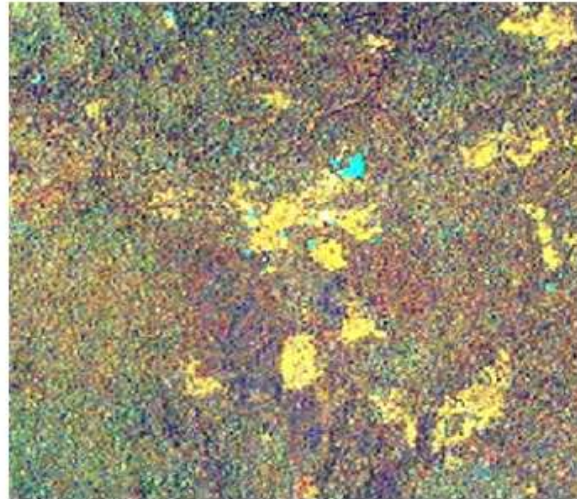


- ➊ Data selection and cloud screening (JRC)
Processing and change detection (UCL)
 - ➋ National experts training
 - ➌ Interactive interpretation by national experts
 - ➍ Statistics computation (nat.& regional levels)
 - ➎ Adoption of statistics as national reference
- ⇒ **National services, SOF 2010 & FRA 2010...**

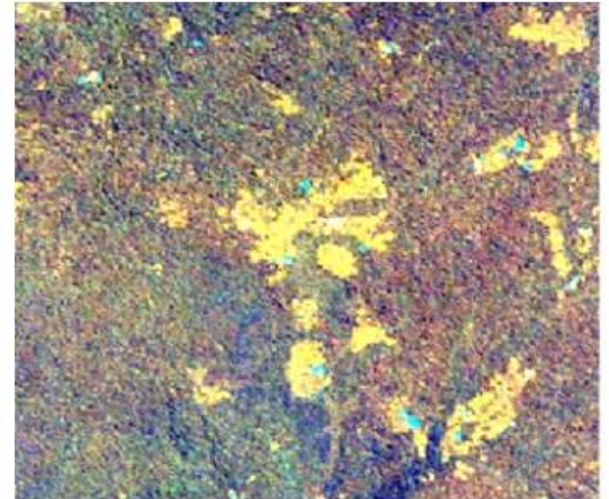
Methodology – Step 1



N00_E025 Landsat TM ± 1990

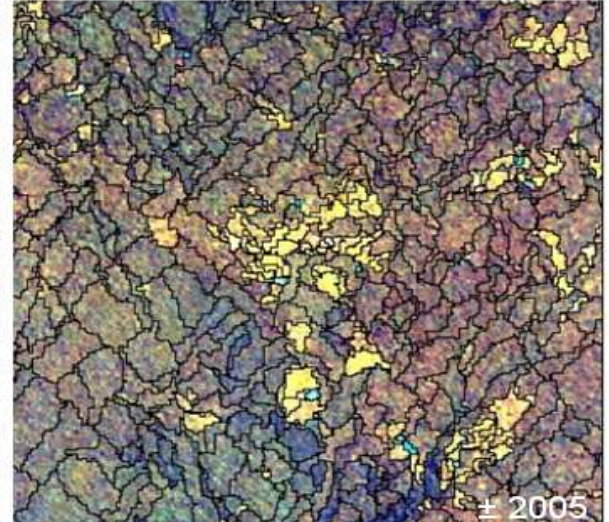
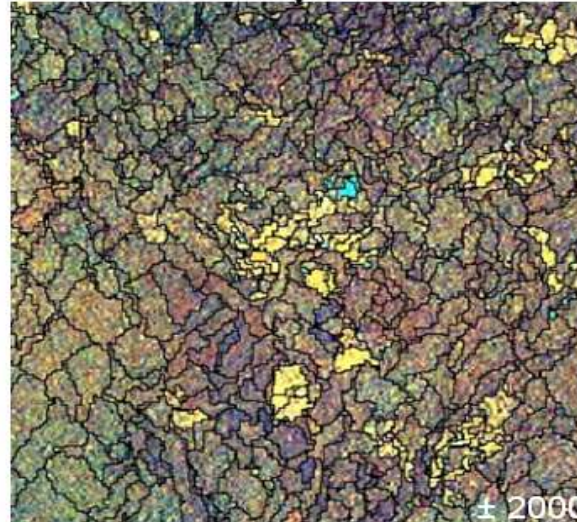
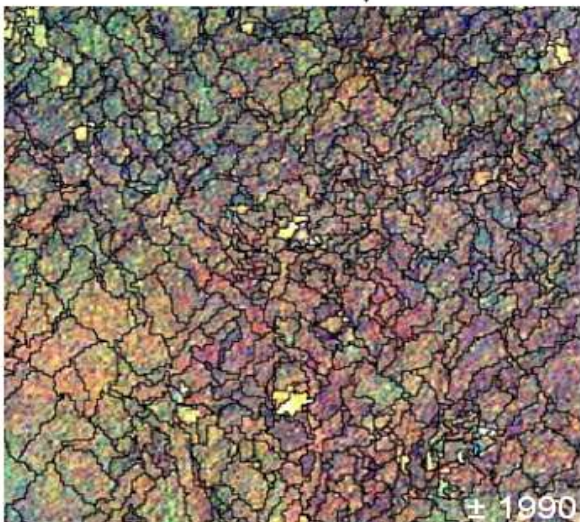


N00_E025 Landsat ETM ± 2000



N00_E025 Landsat ETM ± 2005

MULTI-DATE SEGMENTATION

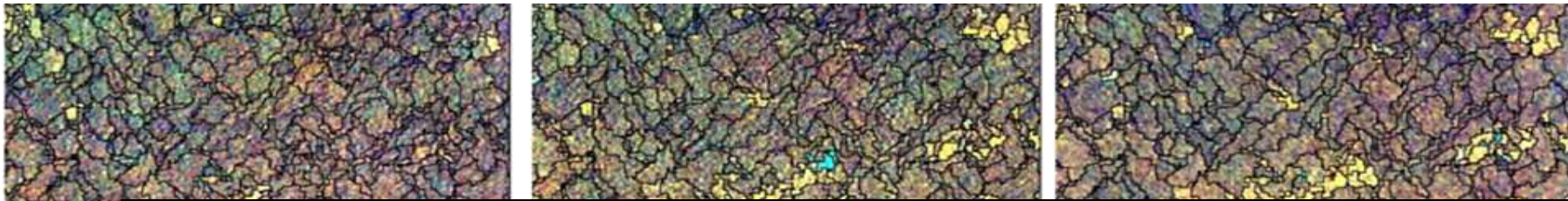


Methodology – Step 1












Automated Processing Chain *(UCL – Duveiller et al., RSE 2008)*

- Object-based algorithms
- Multi-date segmentation (MMU ~ 1 ha)
- Unsupervised classification
- Pre-labeling based on old/coarse land cover maps
- Aggregation (MMU ~ 5 ha) => 5 vegetation classes



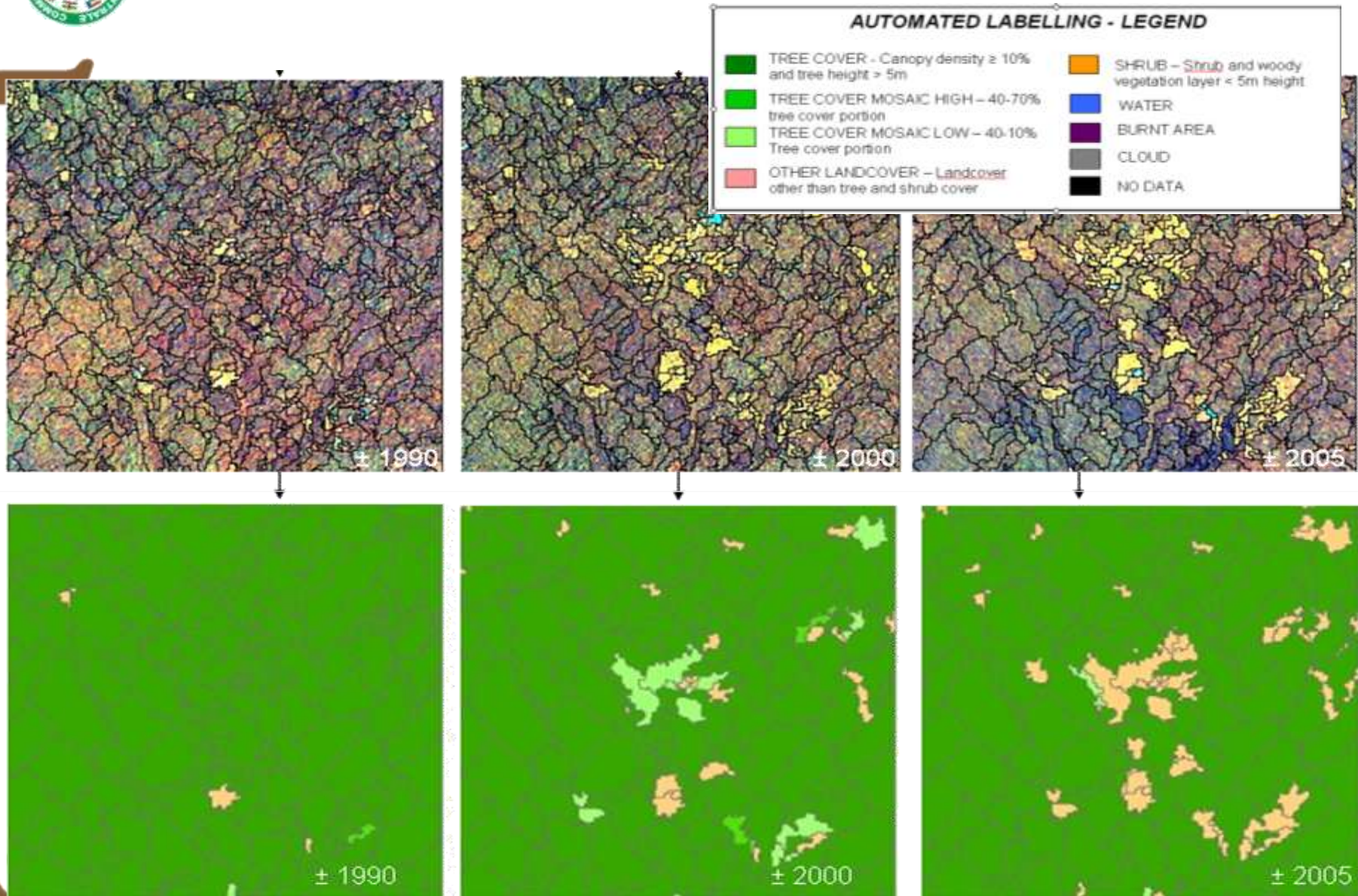
AUTOMATED LABELLING - LEGEND

	TREE COVER - Canopy density $\geq 10\%$ and tree height $> 5\text{m}$		SHRUB – <u>Shrub</u> and woody vegetation layer $< 5\text{m}$ height
	TREE COVER MOSAIC HIGH – 40-70% tree cover portion		WATER
	TREE COVER MOSAIC LOW – 40-10% Tree cover portion		BURNT AREA
	OTHER LANDCOVER – <u>Landcover</u> other than tree and shrub cover		CLOUD
			NO DATA

Methodology – Step 1



Automated Processing Chain *(UCL – Duveiller et al., RSE 2008)*

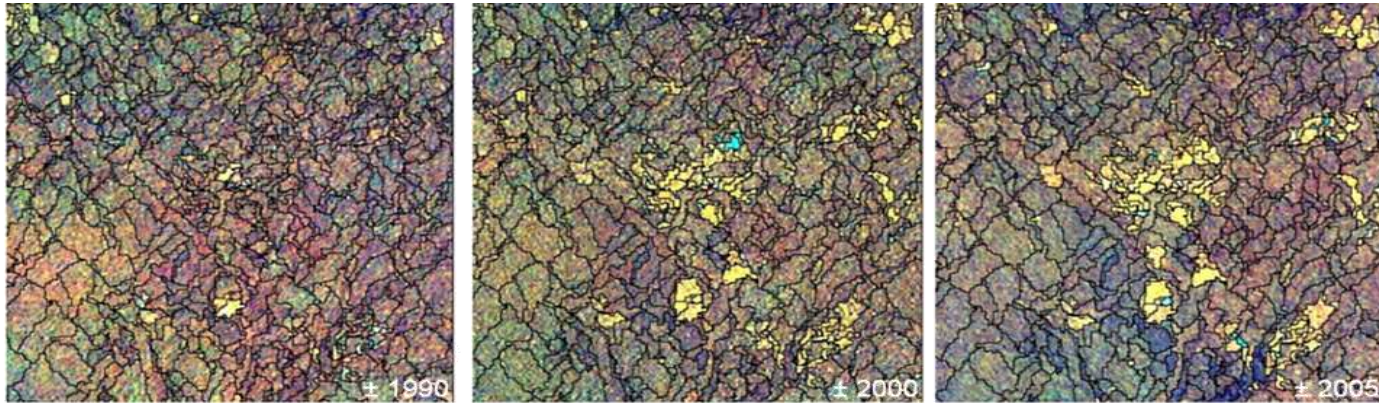




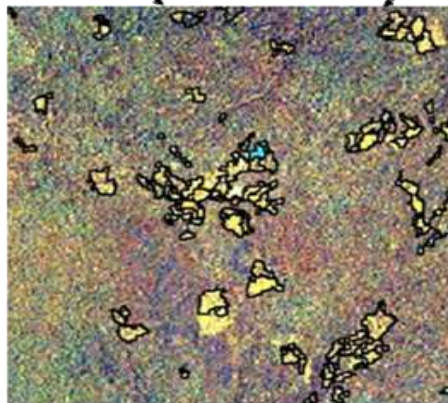
Methodology – Step 1



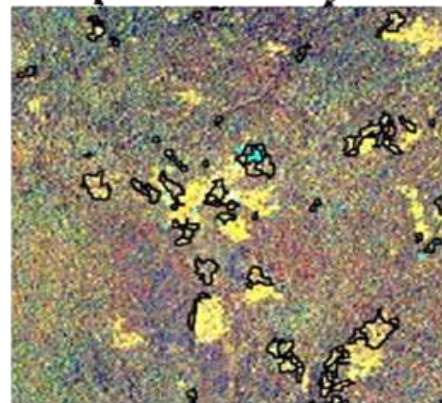
Automated Processing Chain (UCL – Desclé et al., RSE 2006)
- change detection algorithm based statistical trimming



AUTOMATED CHANGE DETECTION



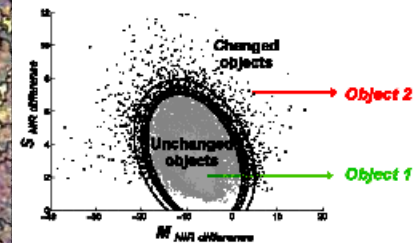
Objects detected as changed between 1990 and 2000



Objects detected as changed between 2000 and 2005

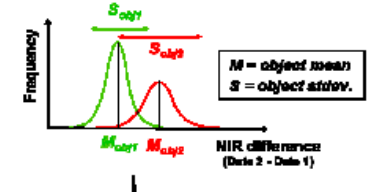
Multivariate iterative trimming

Statistical test to identify changed objects



Object multivariate signature

Two object-statistics (M & S) derived from the reflectance difference bands



Methodology



- ① Data selection and cloud screening (JRC)
Processing and change detection (UCL)
 - ② National experts training
 - ③ Interactive interpretation by national experts
 - ④ Statistics computation (nat.& regional levels)
 - ⑤ Adoption of statistics as national reference
- ⇒ **National services, SOF 2010 & FRA 2010...**

Methodology – Step 2-3



Regional Validation Workshop

Kinshasa, 28 Sept. – 9 Oct. 2009

jointly organized by OFAC, FAO-FRA and JRC

 **15 national experts + international team**



 A validation tool developed by JRC





Methodology – Step 2-3

Intensive and fruitful work !



**Regional Validation Workshop – Kinshasa,
28 Sept.– 9 Oct. 2009**

Methodology



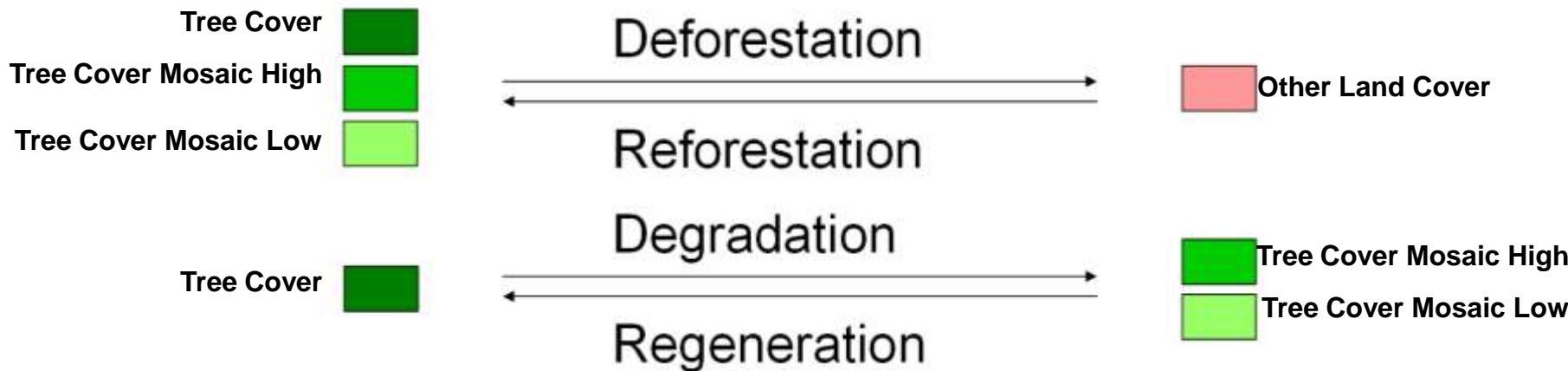
- ① Data selection and cloud screening (JRC)
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Methodology – Step 4

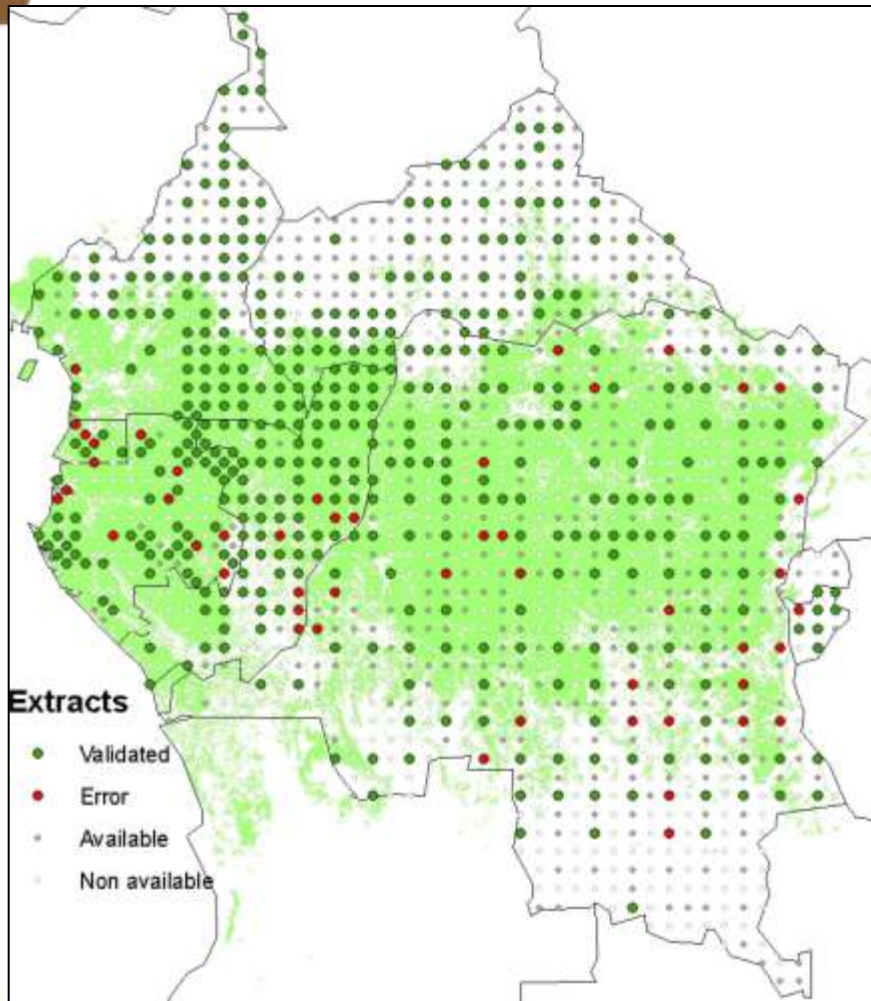
Statistics computation

4 Land Cover Change processes





Methodology – Step 4



National experts

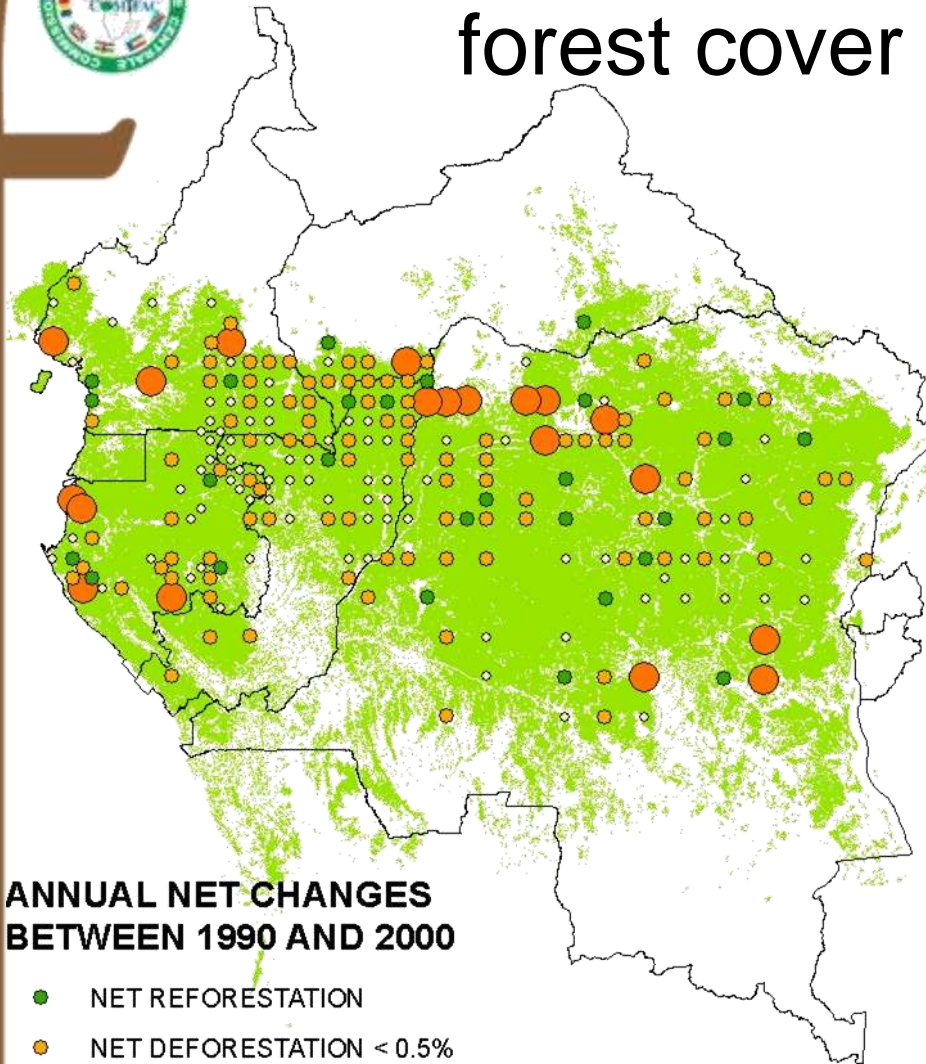
443 samples interpreted

**Great interest for the method,
the validation tool...**

Wonderful work!

	Extracts Disponibles	Extracts Validés	Extracts Erreurs	Extracts Validés 90-00-05	Extracts Validés 90-00	Extracts Validés	
						Degrés FRA 90-00-05	Degrés FRA 90-00
RDC	411	151	27	102	49	78	38
Congo	86	75	8	36	39	10	12
RCA	199	76	1	63	13	30	5
Gabon	60	50	10	10	40	1	9
Guinée Equatoriale	8	4	4	0	4	0	0
Cameroun	119	80	2	45	35	23	7
Burundi	9	7	1	6	1	1	1
Rwanda	5	0	0	0	0	0	0
TOTAL	897	443	53	262	181	143	72

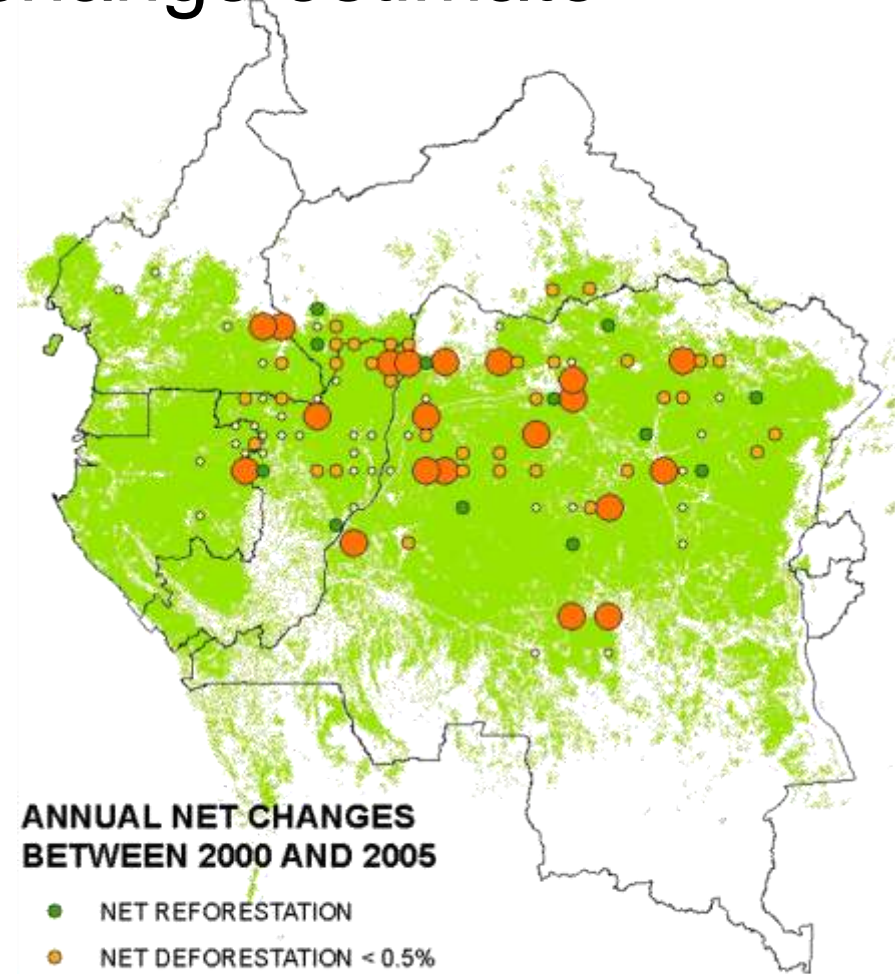
Very preliminary results: already processed extracts for forest cover change estimate



**ANNUAL NET CHANGES
BETWEEN 1990 AND 2000**

- NET REFORESTATION
- NET DEFORESTATION < 0.5%
- NET DEFORESTATION > 0.51%
- NO CHANGE

N= 246



**ANNUAL NET CHANGES
BETWEEN 2000 AND 2005**

- NET REFORESTATION
- NET DEFORESTATION < 0.5%
- NET DEFORESTATION > 0.51%
- NO CHANGE

N= 115

Uncomplete preliminary figures: forest cover change detection for 1990-2000



	Number Of samples	NET DEFORESTATION (90-00)
CAMEROON	42	0.09% ± 0.07%
GABON	46	0.09% ± 0.06%
CONGO -	52	0.07% ± 0.04%
C.A.	15	0.10% ± 0.12%
D.R.	91	0.17% ± 0.07%
CENTRAL AFRICA	246	0.12 % ± 0.03%

Uncomplete preliminary figures: forest cover change detection



ANNUAL NET DEFORESTATION RATES BETWEEN

1990-2000

and

2000-2005

	n (90-00)	NET DEFORESTATION (90- 00) with CI	n (00-05)	NET DEFORESTATION (00-05) with CI
CENTRAL AFRICA	246	0.12 % ± 0.03%	115	0.35% ± 0.16%

=>Final results for forest biome due by March 2010




Lessons learnt and perspectives

- 
Technological and scientific maturity for forest change assessment

=> International effort to enhance the satellite data acquisition strategy (regional receiving station, SAR coverage)

- 
Capacity building and technology transfer needed to support **national ownership**

- 
Observatory of Central African Forests : a very efficient collaborative framework capitalizing various efforts
 => **consolidated estimate at national level by March 2010**
 => follow-up for 2005-2010 already planned