VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

Joint GFOI / GOFC-GOLD / CONABIO / SilvaCarbon R&D Expert and Capacity Building workshop on:

Regional solutions to forest type stratification and characterising the forest state for national forest monitoring and carbon emissions reporting (REDD+ MRV and LULUCF)

Integration methods for forest degradation assessment and change monitoring

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CONABIO, Mexico City
June 7-10, 2016

Global Forest Observations Initiative

GOFC-GOLD
Global Observation of Forest Cover and Land Dynamics
Land Cover Project Office

SilvaCarbon

CONABIO
COMISIÓN NACIONAL PARA EL CONOCIMIENTO Y USO DE LA BIODIVERSIDAD

Project Background

1. Describe briefly the context and geographical location

- Mapping forest cover and change including degradation
- Accuracy assessment, statistical data provision
- Optical & SAR

Projects

- Mexico:
  - Recover EU Oct 2010 – Dec 2013: Chiapas Partners COLPOS, ECOSUR; Cooperation SEMANH (Regional government), CONABIO
  - Forestry Thematic Exploitation platform ESA: Chiapas & Durango; Cooperation SEMANH et al. in Chiapas, Univ. Durango
  - Accucarbon ESA: sites in Chiapas & Durango
- Laos: Finnish Aid
- Africa: ESA projects

Project Background

2. Identify the forest types being mapped

- Humid tropics, sub-tropical

3. Describe how the information is used (e.g., national inventory and/or emissions reporting)

- Support to develop MRV of REDD+, National forest inventories

Methods

1. Describe your current approach to forest stratification mapping and/or characterising the forest state

a) Forest cover mapping

The SilvaSat concept

"Wall-to-wall" optical or radar satellite data - medium to low resolution

Maps with variable or unknown accuracy

SilvaSat – sample of very high resolution images

Reliable statistical data on forest and land cover - feasible, with reasonable costs

Ground measurements

Reliable statistical data, many variables
- expensive, can be unfeasible to collect

Maps with known and harmonized accuracy

Statistical data with reduced field sampling rate, many variables, Including biomass

Maps with known and harmonized accuracy, many variables

0.5 m

1.0 m

2.0 m

120 m x
120 m

5 m

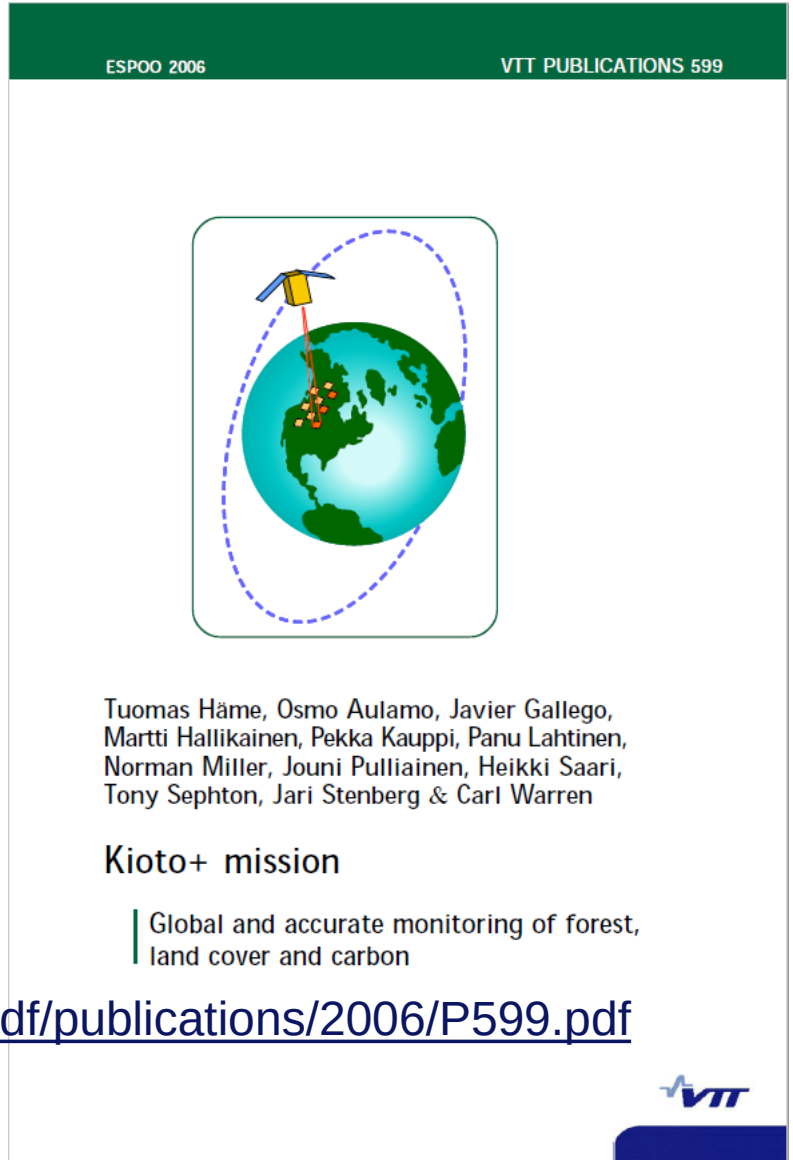
10 m

20 m

30 m

WV Apr 4 2012, Chiapas, Mexico – Block filtered

Proposal made to ESA on public VHR sampling satellite



ESPOO 2006 VTT PUBLICATIONS 599

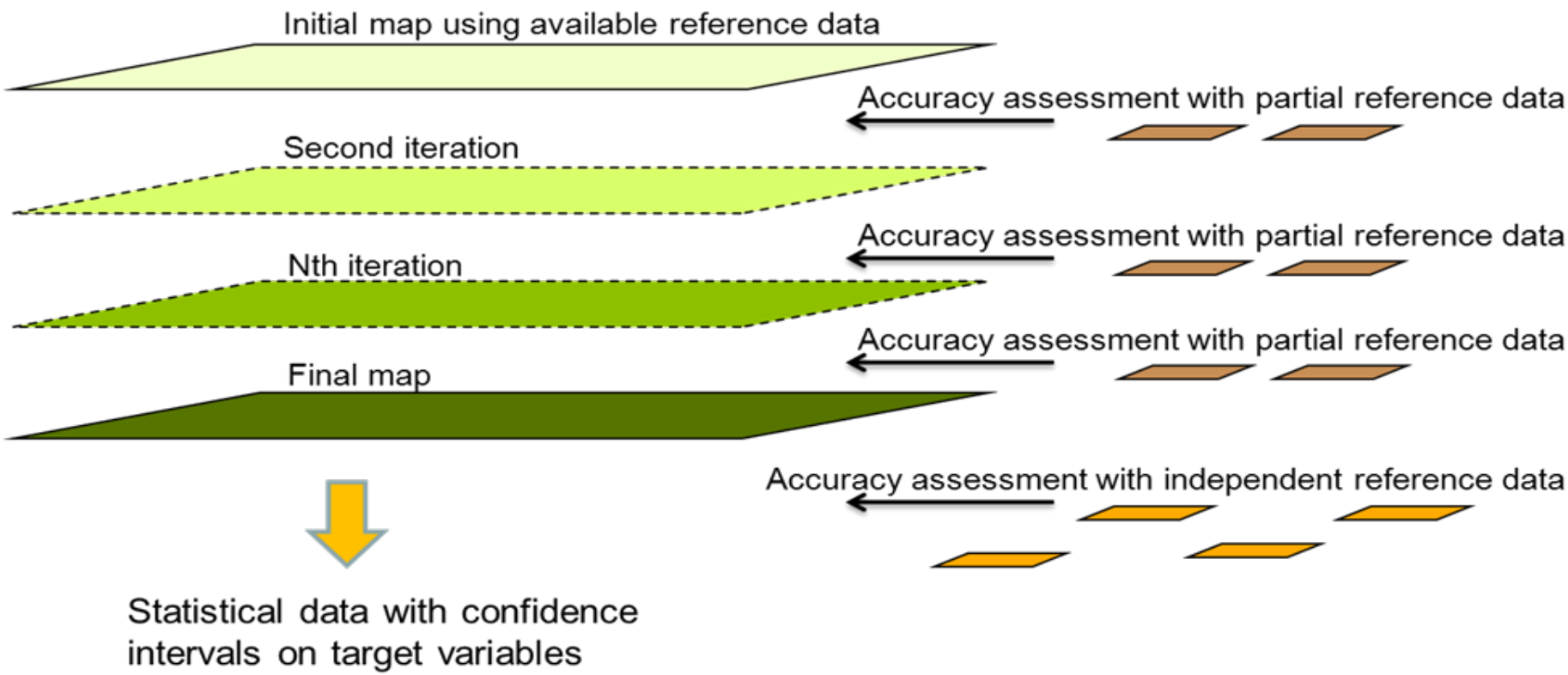
Tuomas Häme, Osmo Aulamo, Javier Gallego, Martti Hallikainen, Pekka Kauppi, Panu Lahtinen, Norman Miller, Jouni Pulliainen, Heikki Saari, Tony Sephton, Jari Stenberg & Carl Warren

Kioto+ mission

Global and accurate monitoring of forest, land cover and carbon

http://www.vtt.fi/inf/pdf/publications/2006/P599.pdf

Iterative mapping process



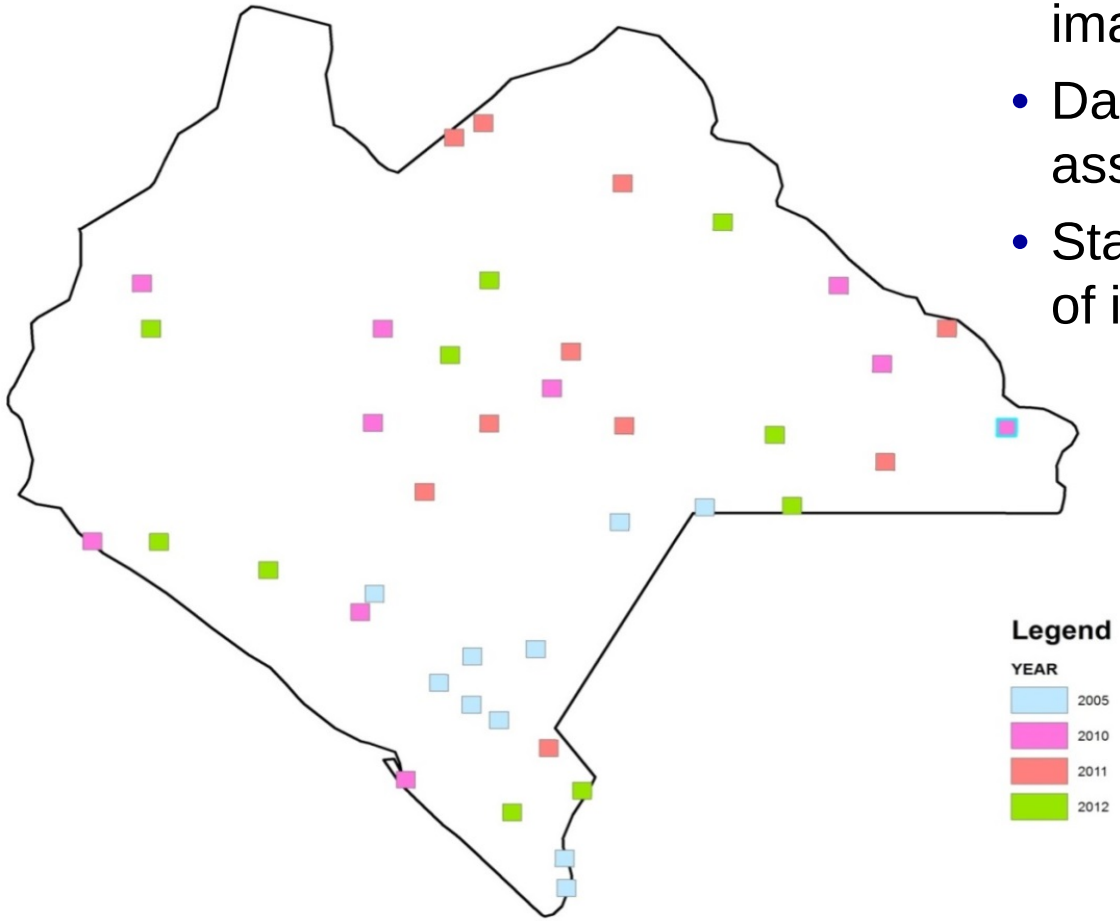
Training and accuracy assessment

- Set A & B: training and reduction of bias
  - Initial model with set A
  - Acc. assessment with set A
  - Optional model adjustment
  - Acc. Assessment with set B
  - Optional model adjustment
- Set C: Actual accuracy assessment
  - No model adjustment
  - Overall accuracy, user's and producer's accuracies

Two-stage sampling

First stage:

- sample of VHR images

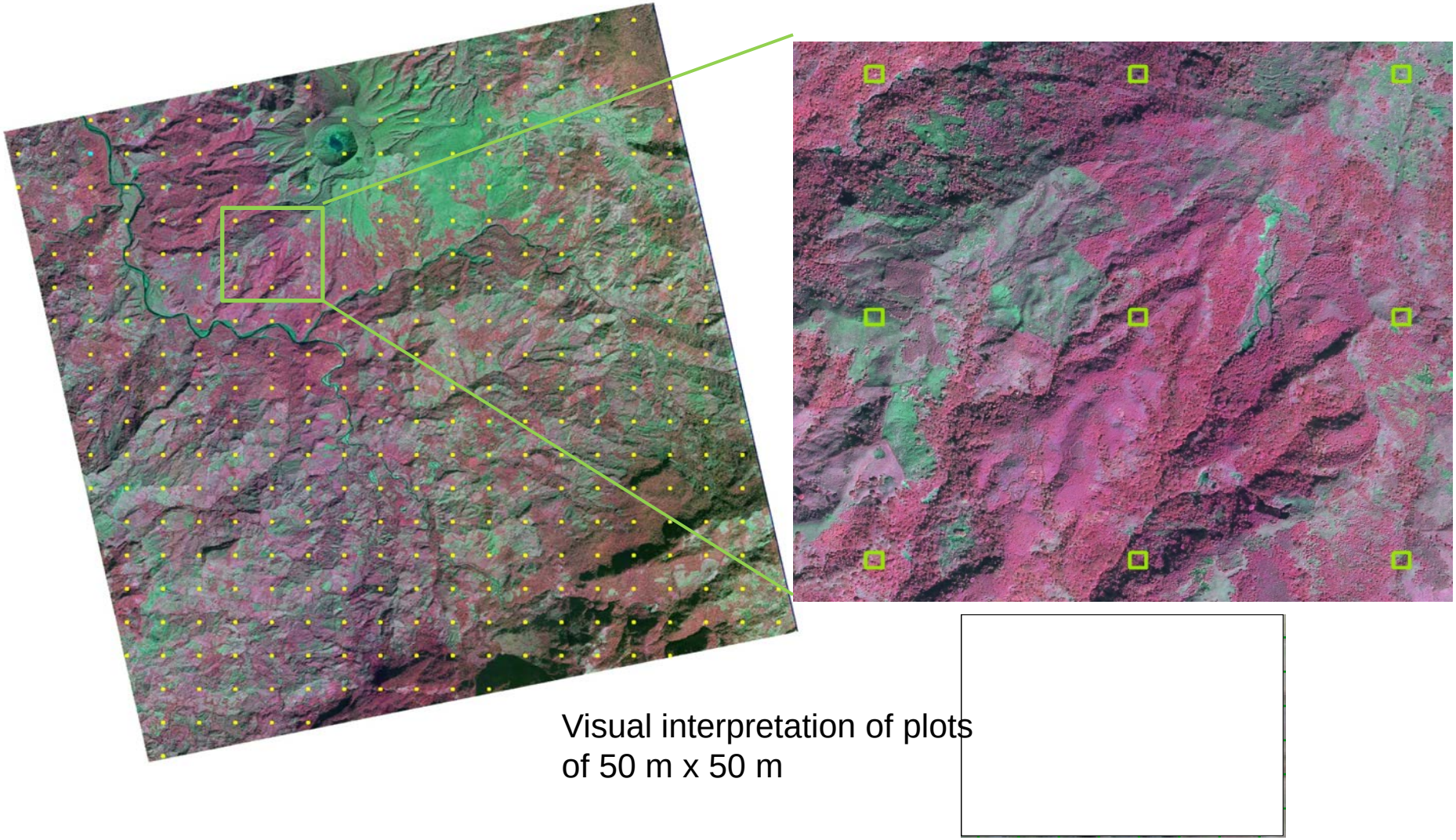


Second stage:

- Sample of plots within the VHR images
- Data for training and accuracy assessment
- Statistical information on variables of interest

Häme et al. 2013. IEEE JSTARS

Sample plots of VHR data

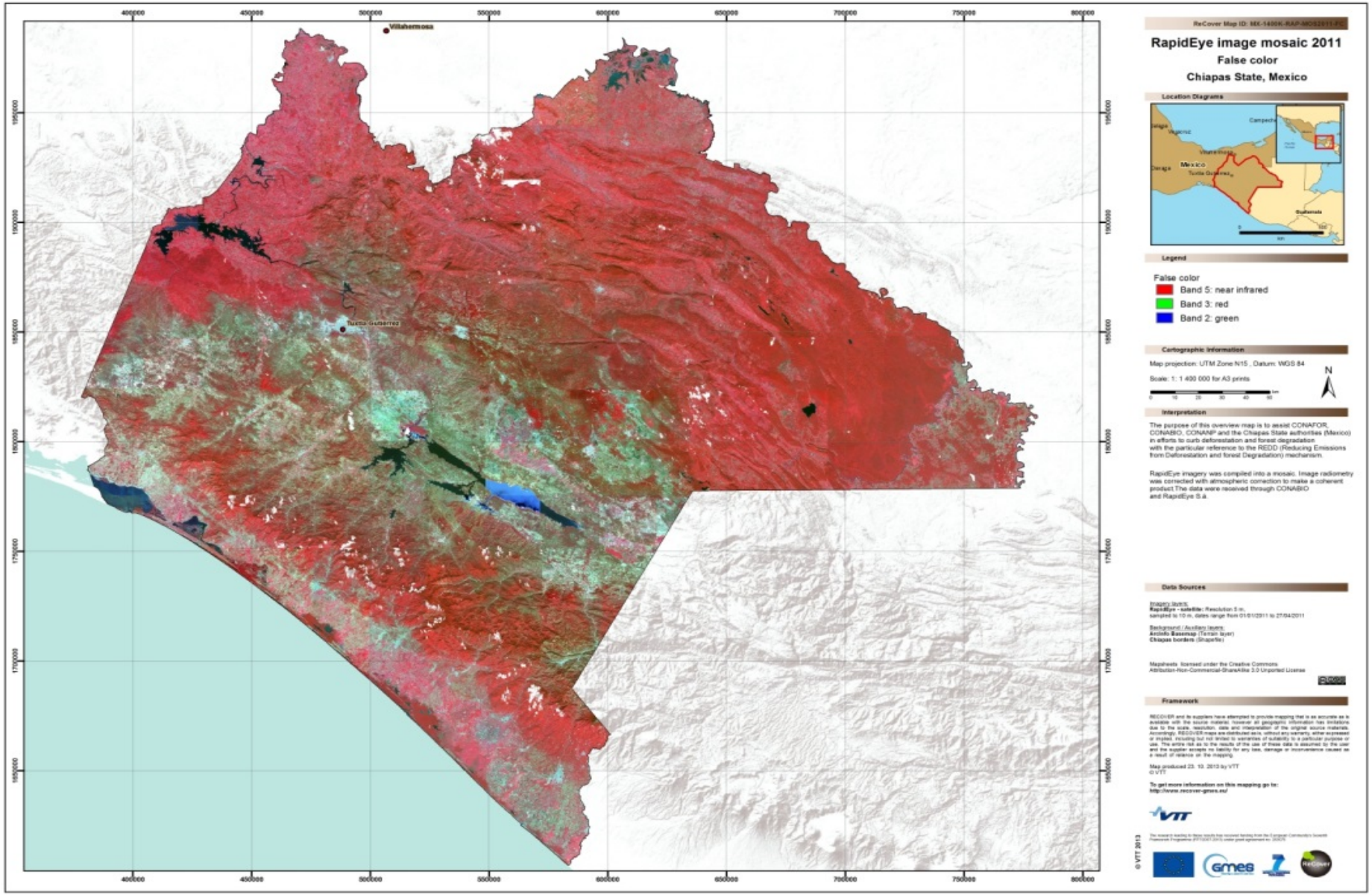


Visual interpretation of plots
of 50 m x 50 m

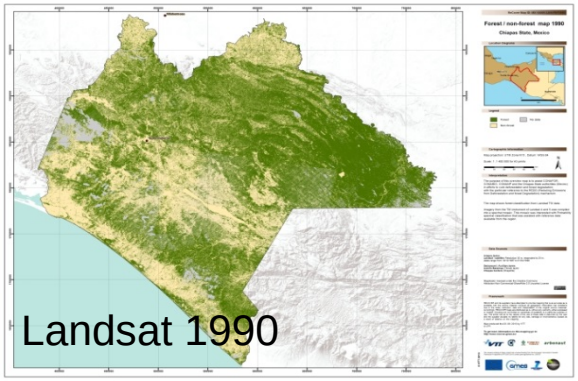
A sample of class definitions applied in Chiapas

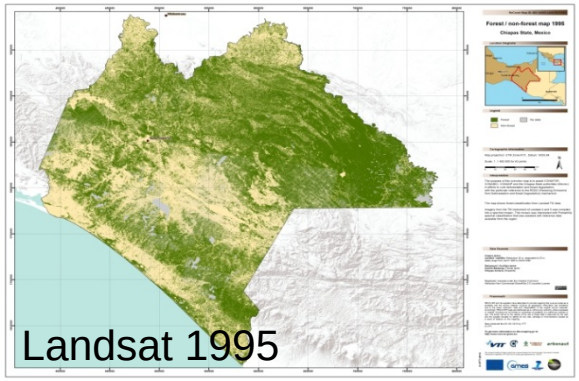
Name in ArcGIS Table	Class name	Description
Cultiv	Cultivated and Managed Terrestrial Areas	Areas where natural vegetation has been removed or modified and replaced by other types of vegetative cover of anthropogenic origin. All vegetation that is planted or cultivated with intent to harvest. Agricultural fields except paddy rice. Unit %.
Nat_for	Natural undisturbed forest	Forest that is in natural condition and no clear signs of degradation are visible. Height more than 5 m, crown closure at least 10 %. (Usually in natural forest the height is much larger). Unit %.
Nat_crown	Crown closure of natural forest	The projected area of tree crowns as the proportion of the total natural forest area. Unit %.
Dstrb_for	Disturbed forest	Forest or woodland area which has re-grown after a major disturbance such as fire, insect infestation, timber harvest or windthrow, also natural forests that show clear signs of degradation due to selective cuttings, for instance. Height more than 5 m, crown closure at least 10 %. Unit %.
Dstrb_crown	Crown closure of disturbed forest	The projected area of tree crowns as the proportion of the total disturbed forest area. Unit %.

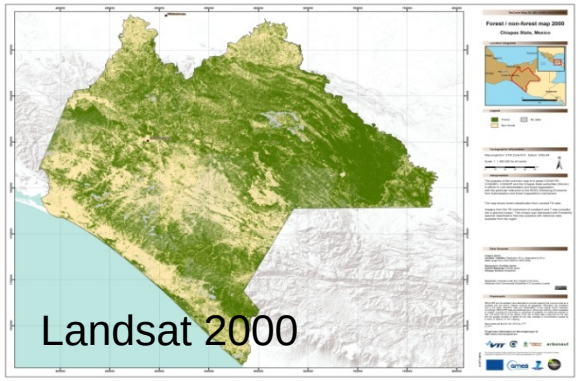
Image mosaic maps

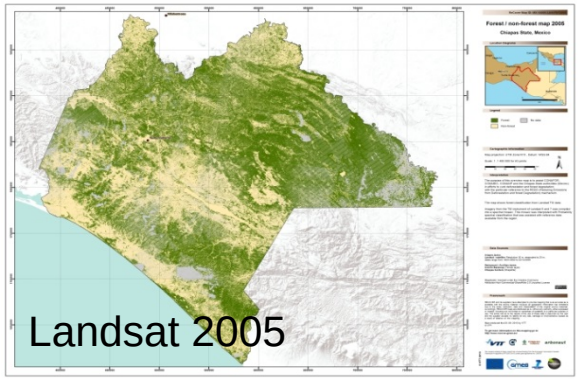


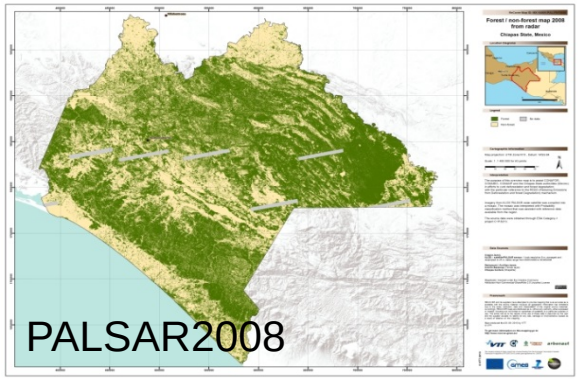
Forest - non-forest maps from optical and PALSAR

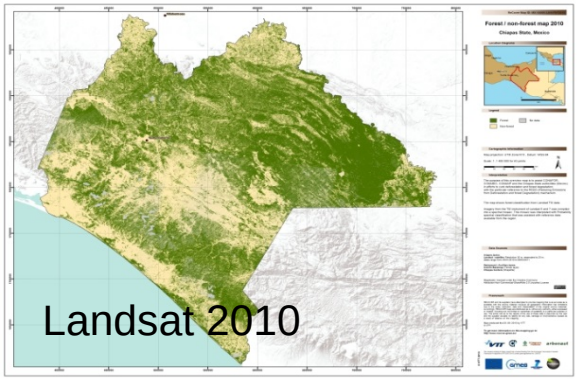


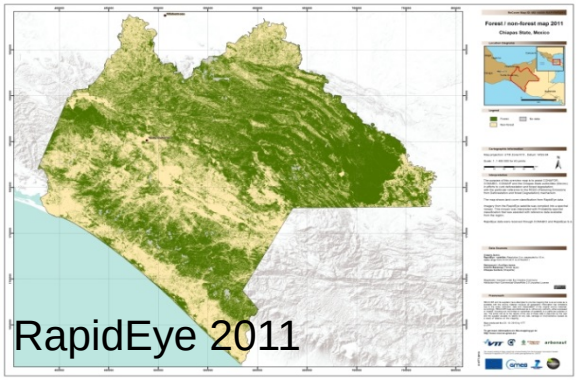


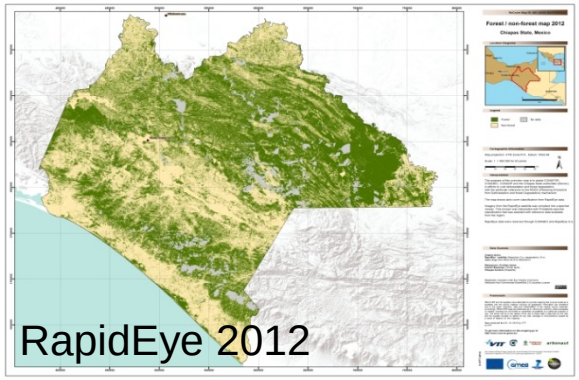




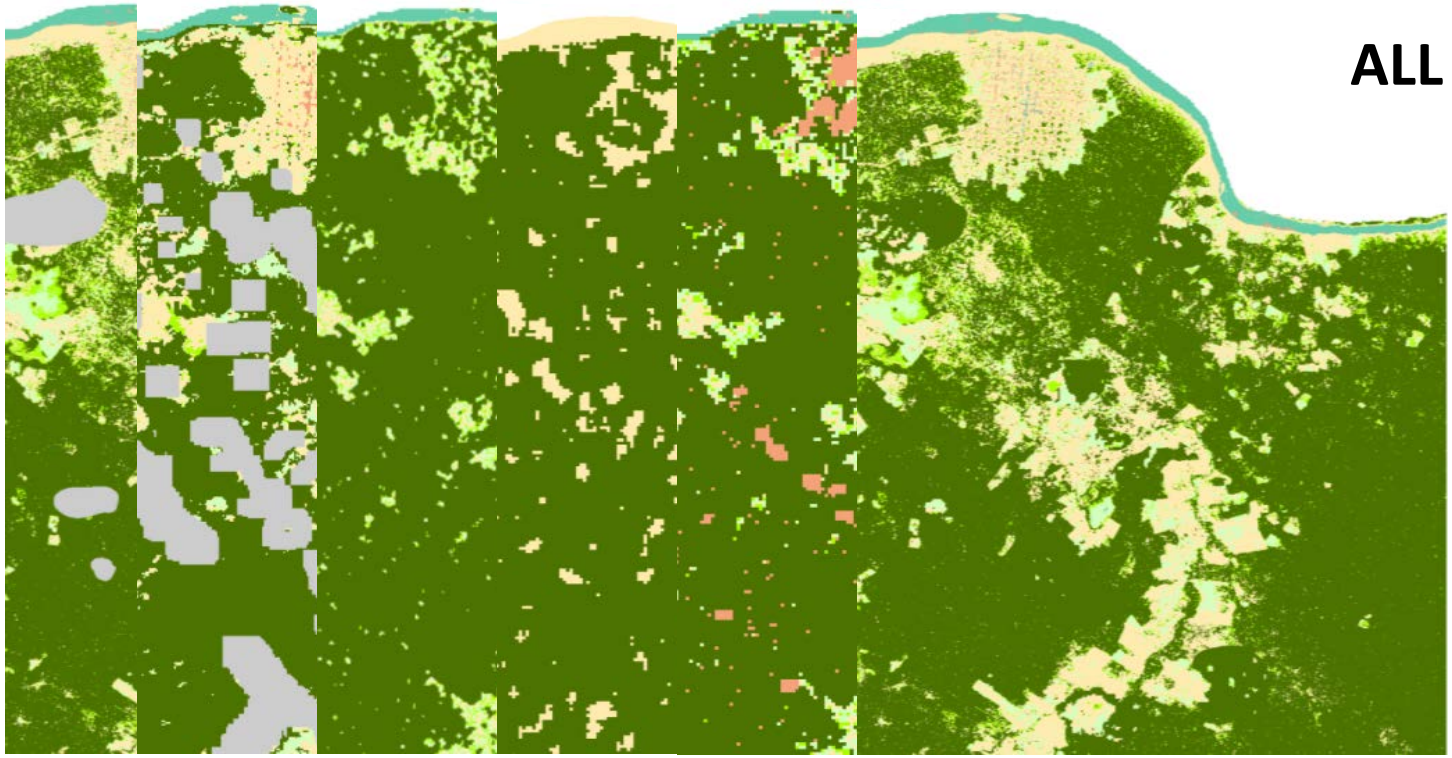


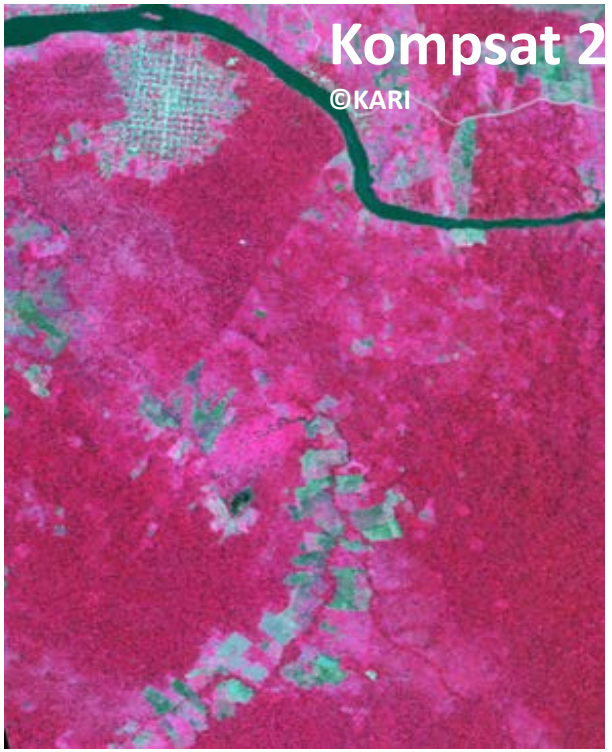






A map detail



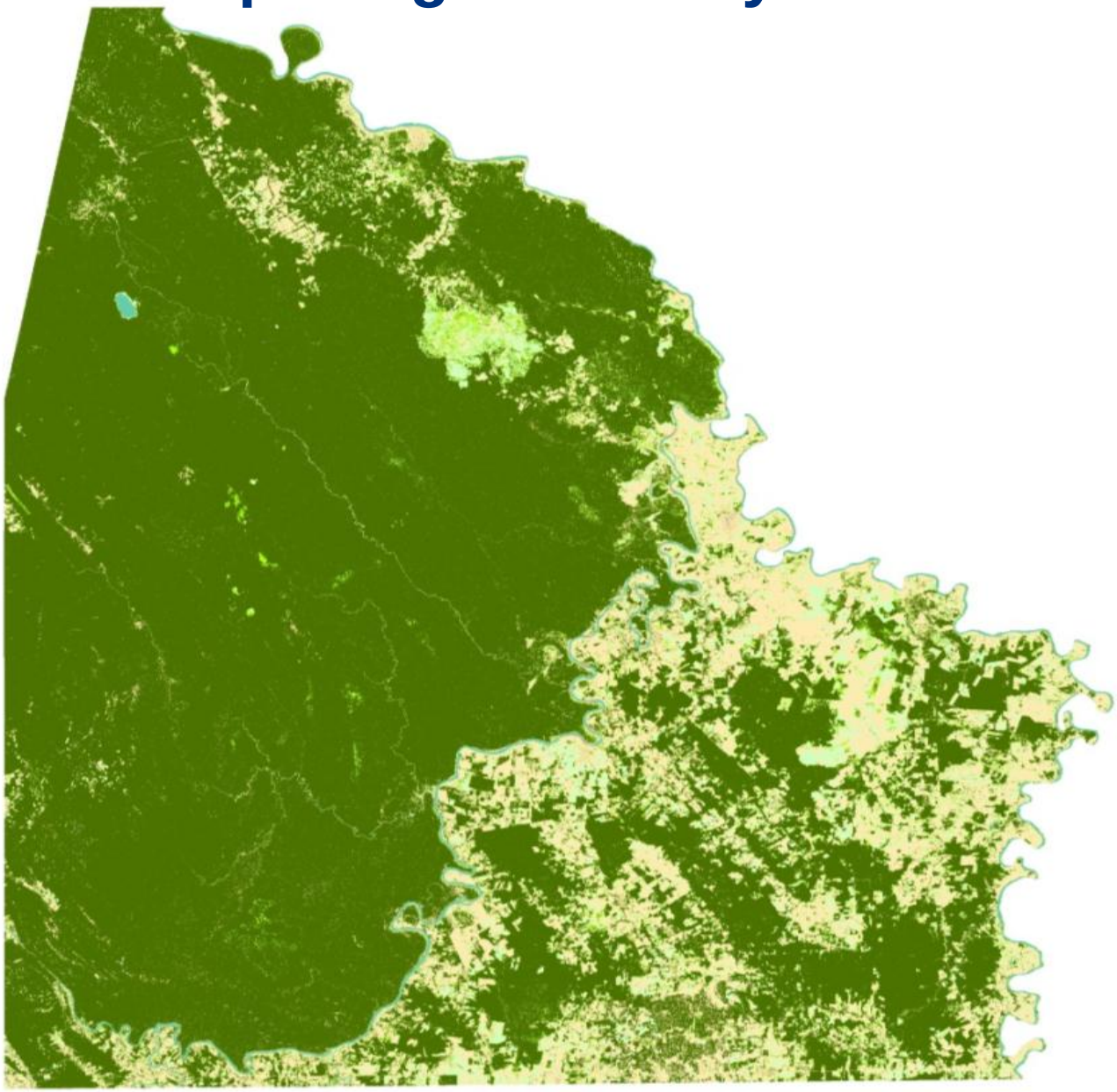


Sirro et al ESA Living Planet 2013
Häme et al ESA Living Planet 2013

	Forest land		Wetlands
	Shrub		Settlements
	Cropland		Other land
	Grassland		No data

Size of the area
~ 12 km x 8 km

Cloudy optical maps augmented by SAR classifications



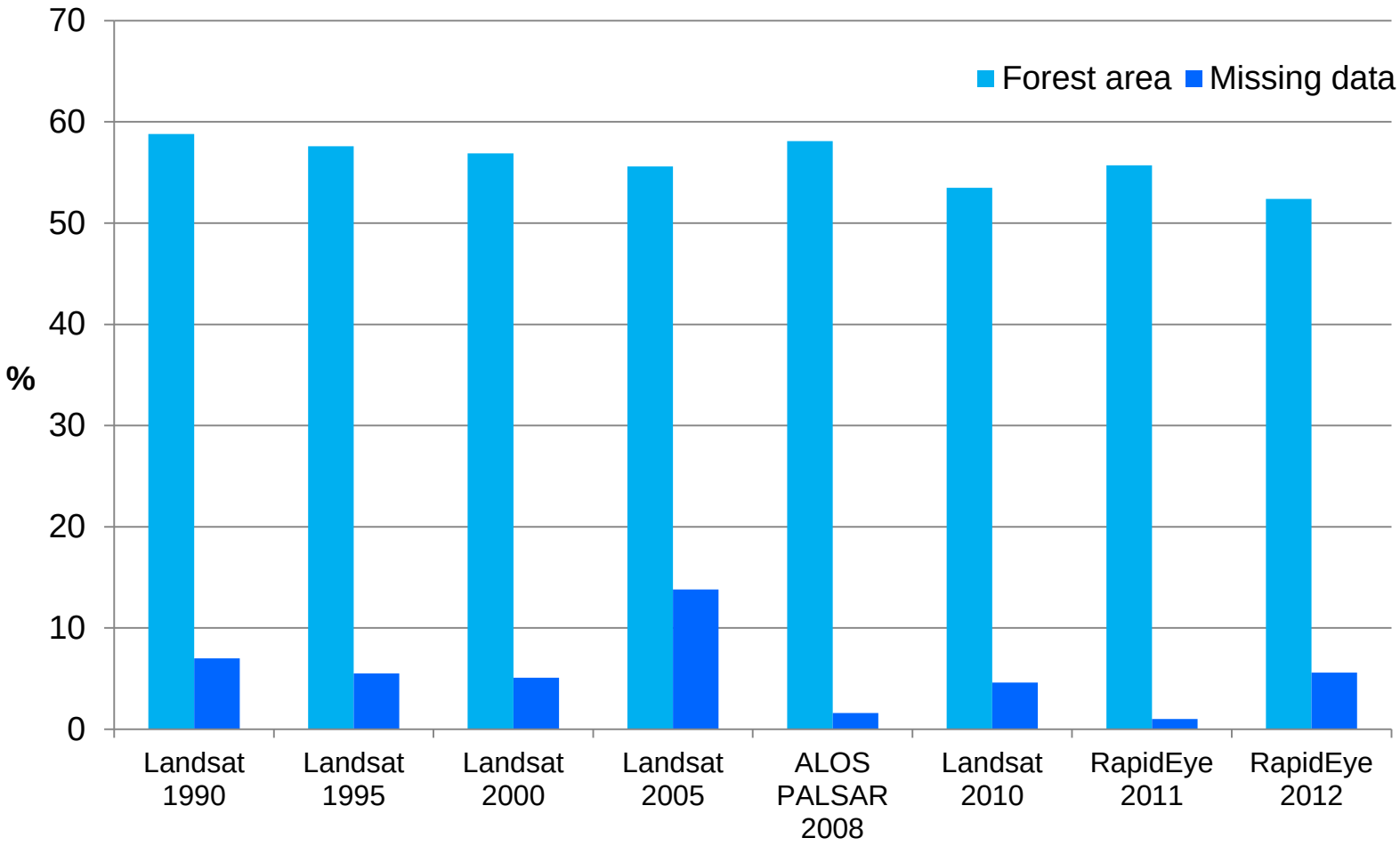
Accuracy assessment results – Chiapas sub-area

Source data	Overall accuracy (forest non-forest)	Overall accuracy (six classes)	Om. error for forest class	Comm. error for forest class	Num. obs.	Proportion of the mapped area from the whole test area
RapidEye	94 %	86 %	7 %	2 %	704	87 %*
Landsat	91 %	86 %	7 %	5 %	392	51 %
PALSAR	89 %	82 %	6 %	8 %	805	98 %
ASAR	76 %	-	16%	17 %	798	96 %
PALSAR+ ASAR	89 %	81 %	7 %	8 %	765	95 %

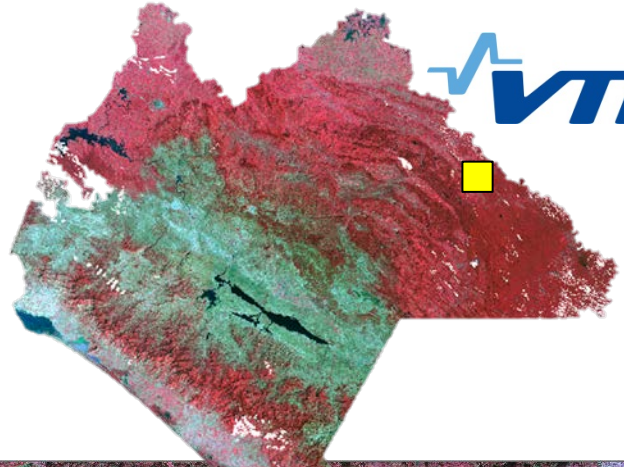
*

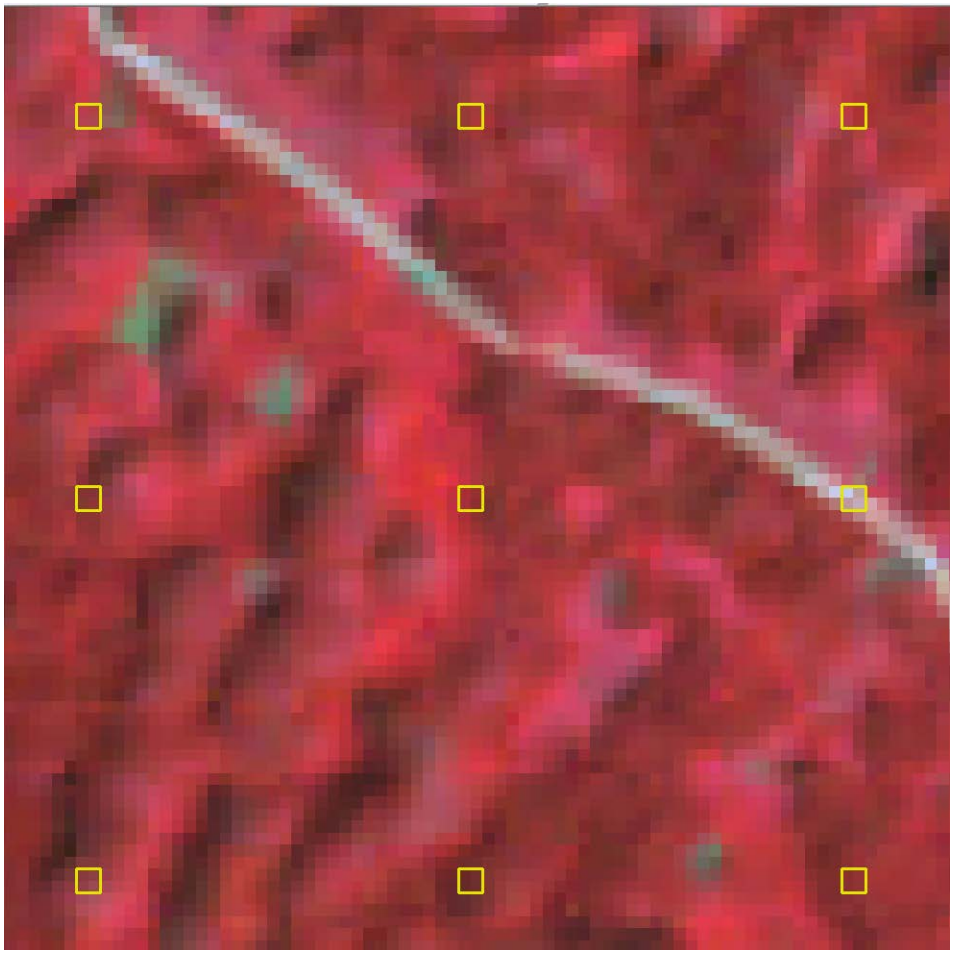
Sirro et al ESA Living Planet 2013

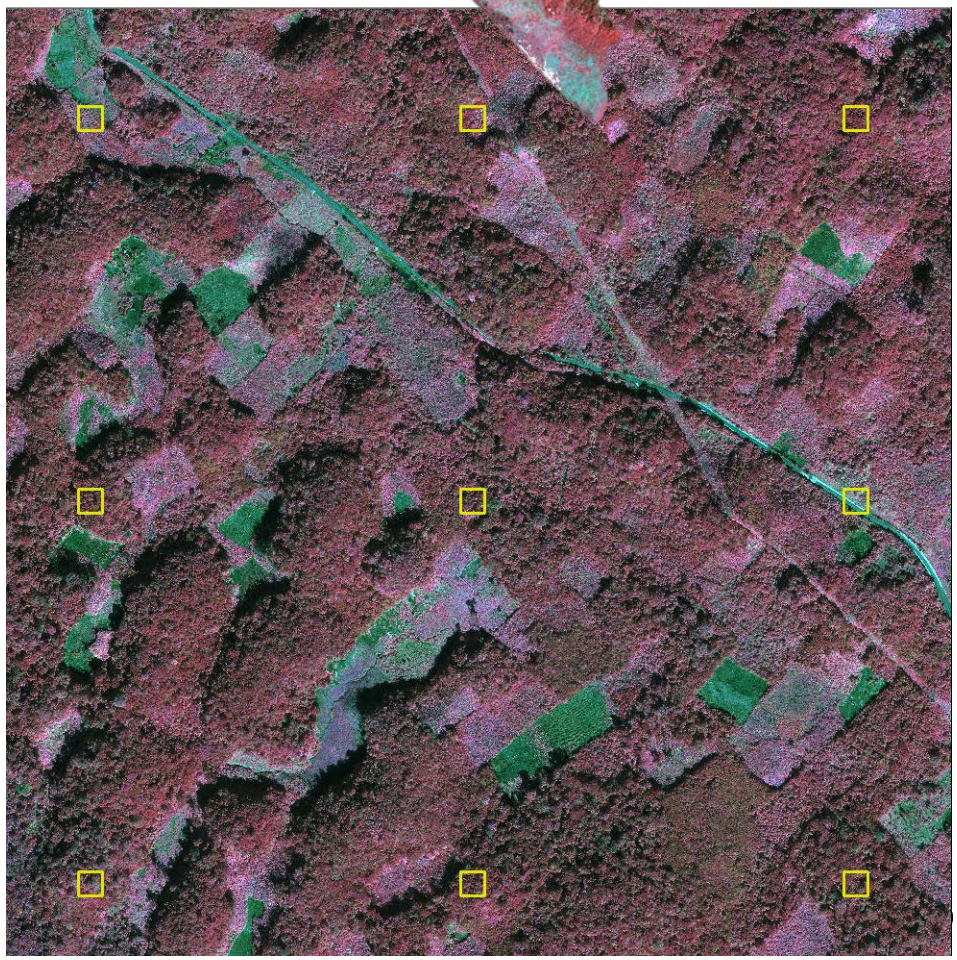
Forest area estimate for state Chiapas, Mexico



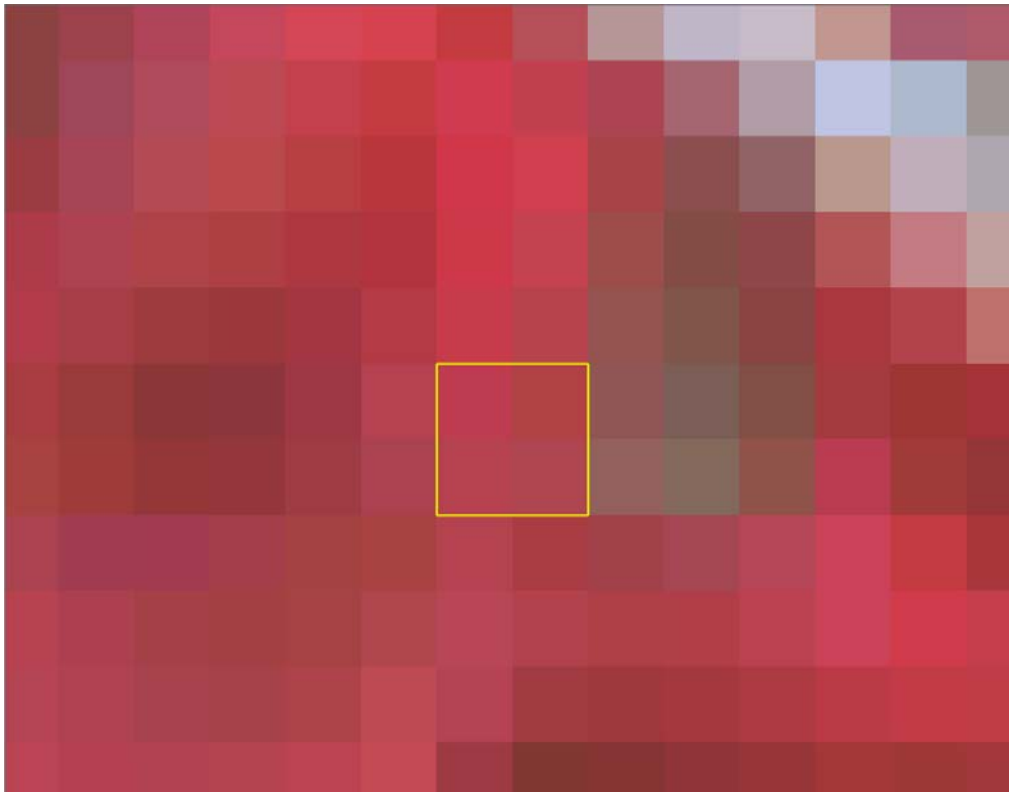
Landsat mosaic 1990 and GeoEye-1 image from December 16th 2010

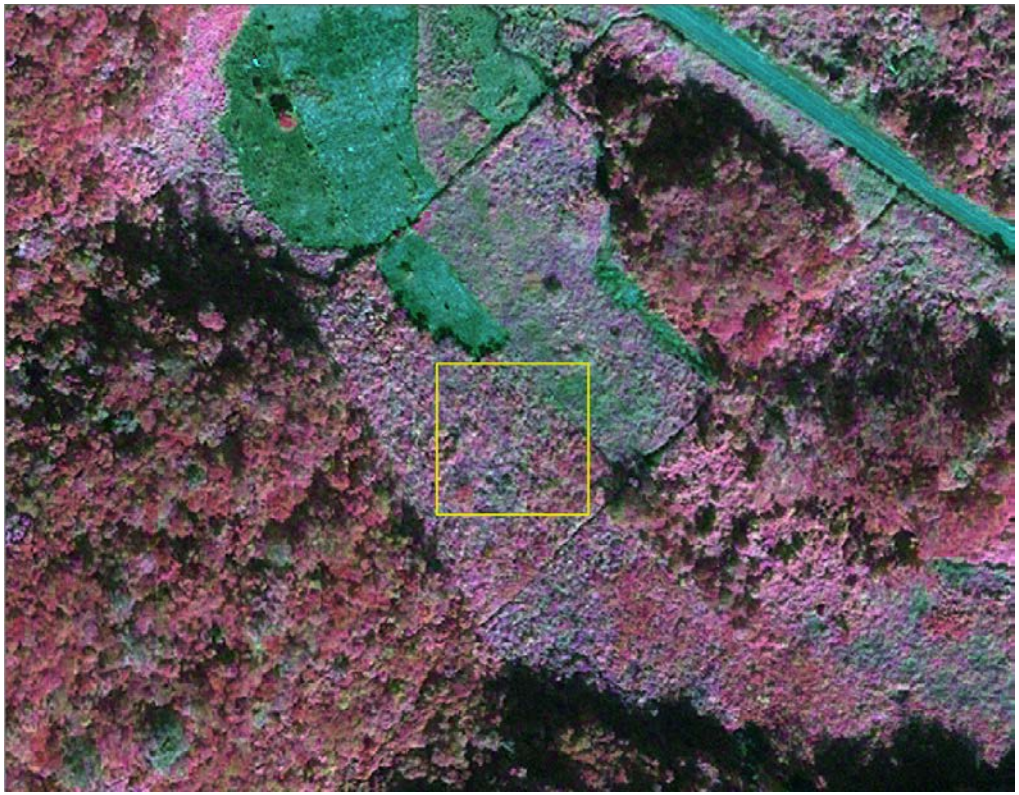




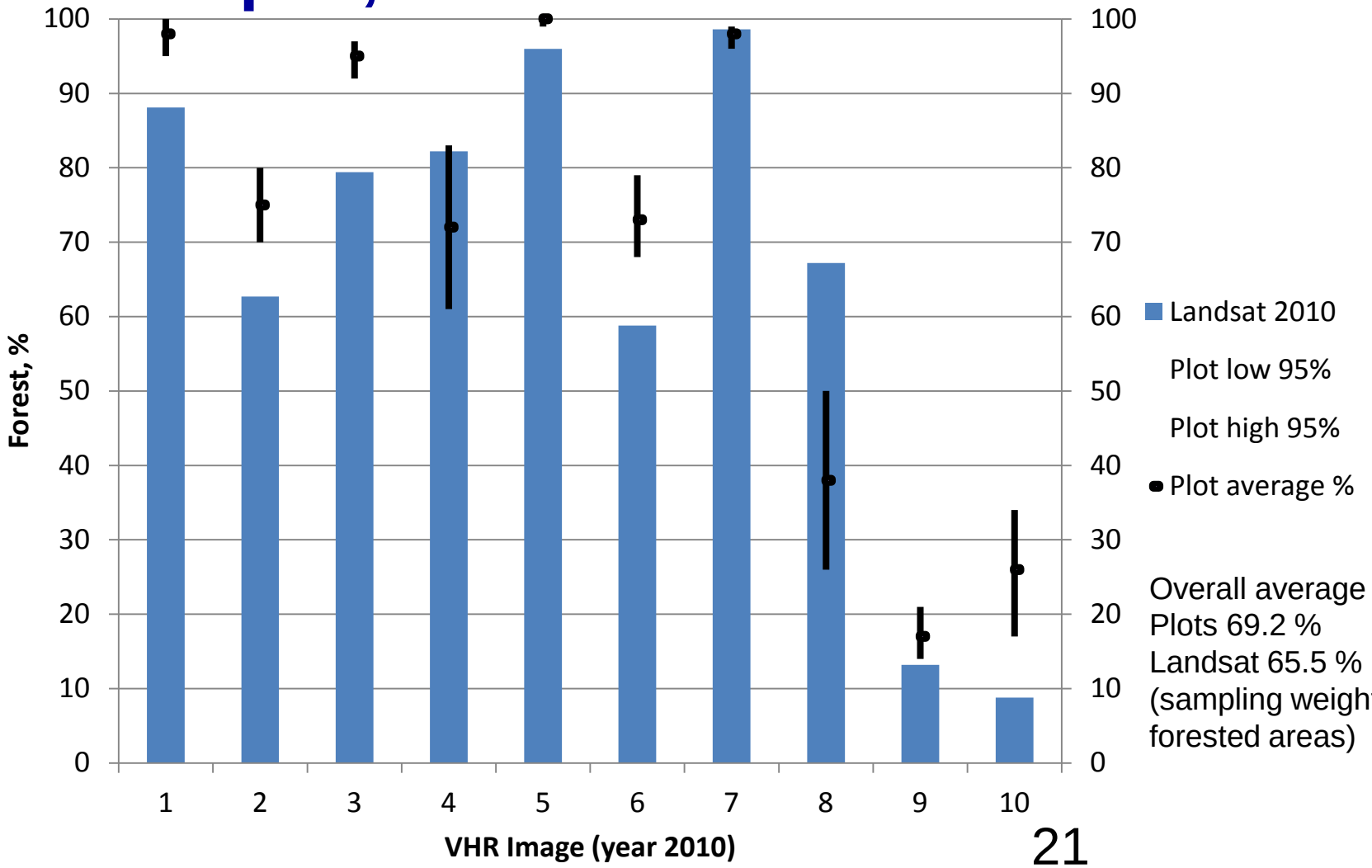


Landsat mosaic 1990 and GeoEye-1 image from December 16th 2010





Forest areas within VHR image areas in 2010 Chiapas, Mexico



Overall average
Plots 69.2 %
Landsat 65.5 %
(sampling weighted to forested areas)

AVNIR (optical) vs. PALSAR accuracies

Savannakhet, Laos

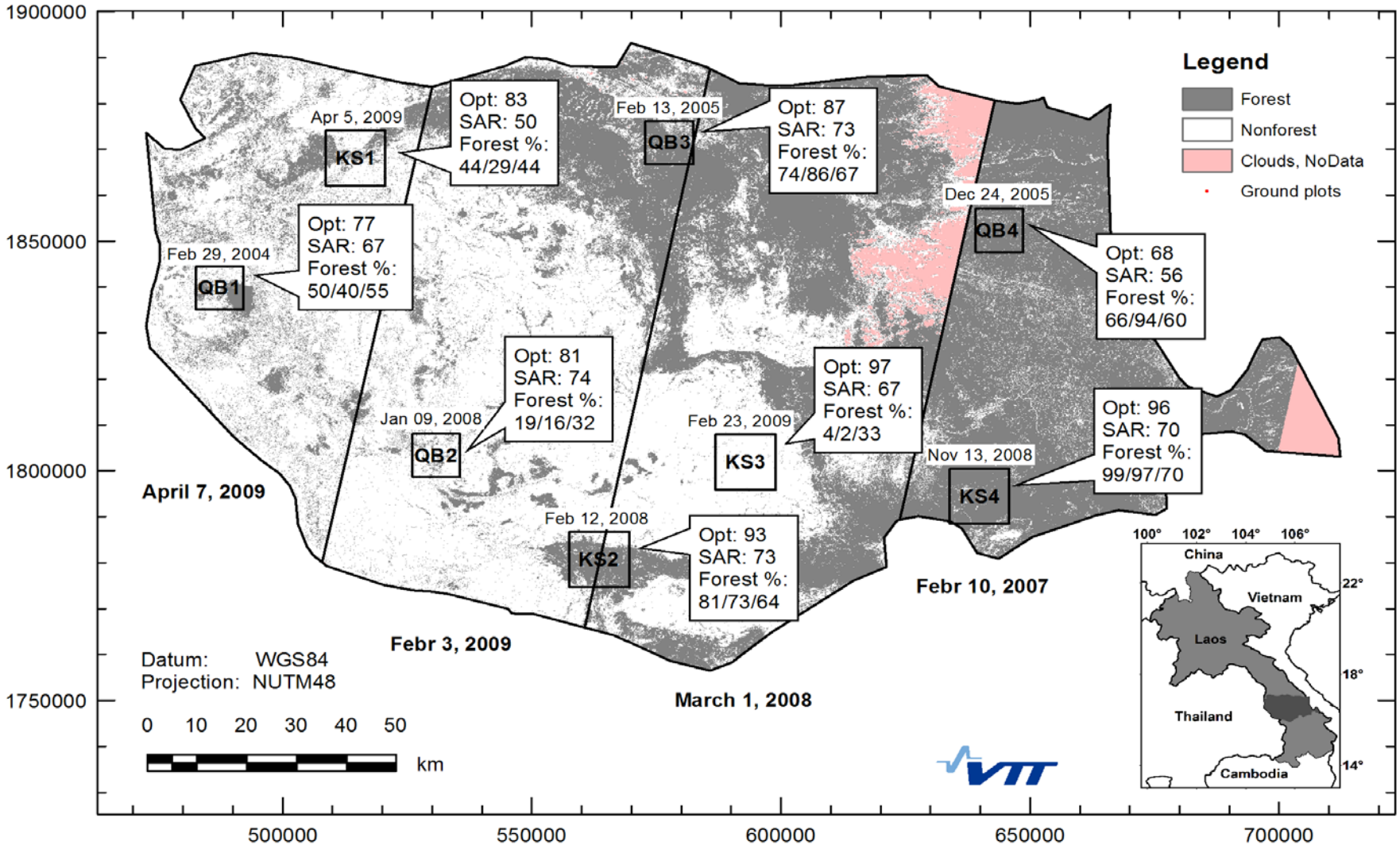


Fig. 9. Overall accuracies of AVNIR (Opt.) and PALSAR (SAR) classifications to forest/non-forest and forest percentages from VHR plots (first value), AVNIR map (second value), and PALSAR map (third value) over a VHR image area. Dates of the acquisition of AVNIR data and image strip borders shown under the map. Häme et al JSTARS 2013

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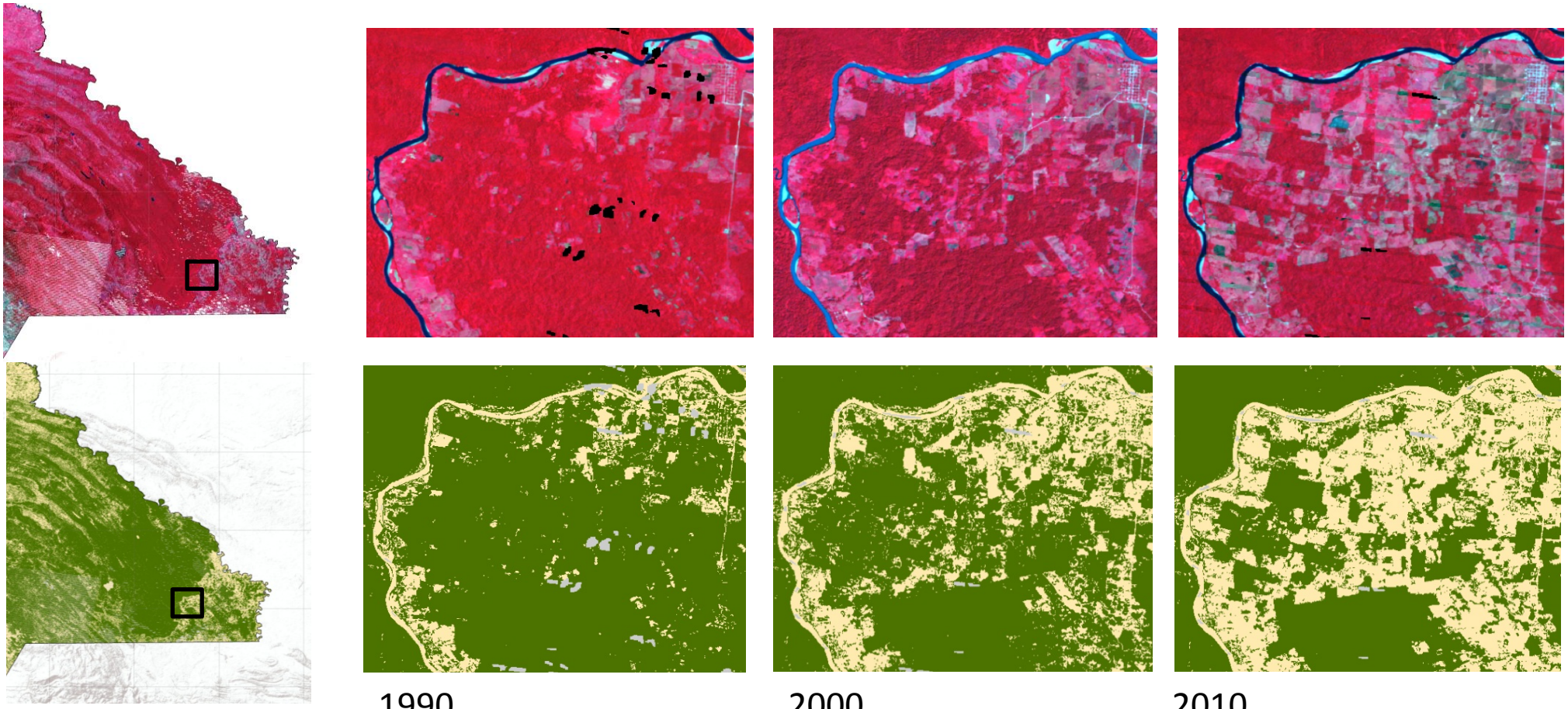
Methods

1. Describe your current approach to forest stratification mapping and/or characterising the forest state

b) Disturbance - degradation

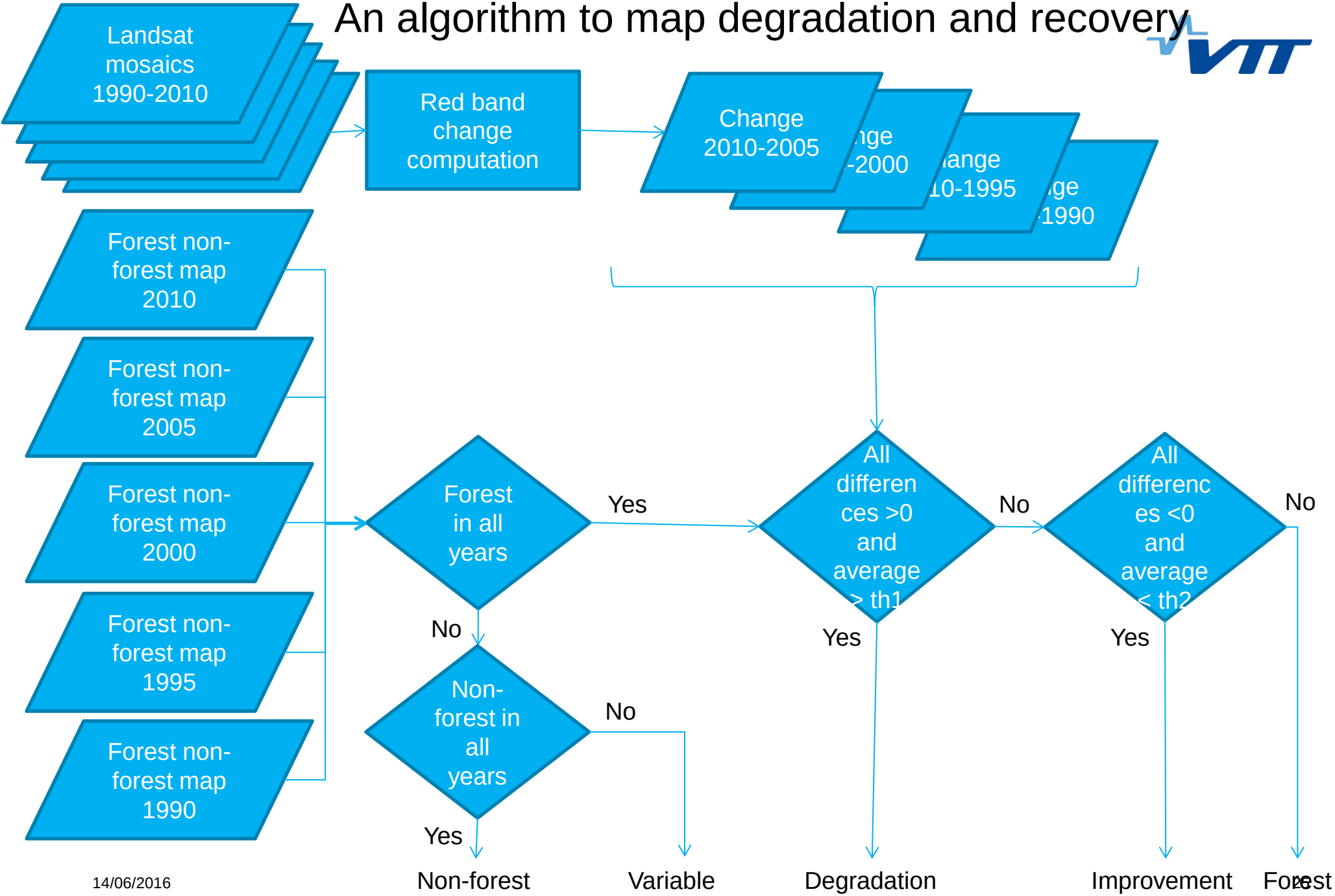
Service for Mexico: change between 1990 and 2010



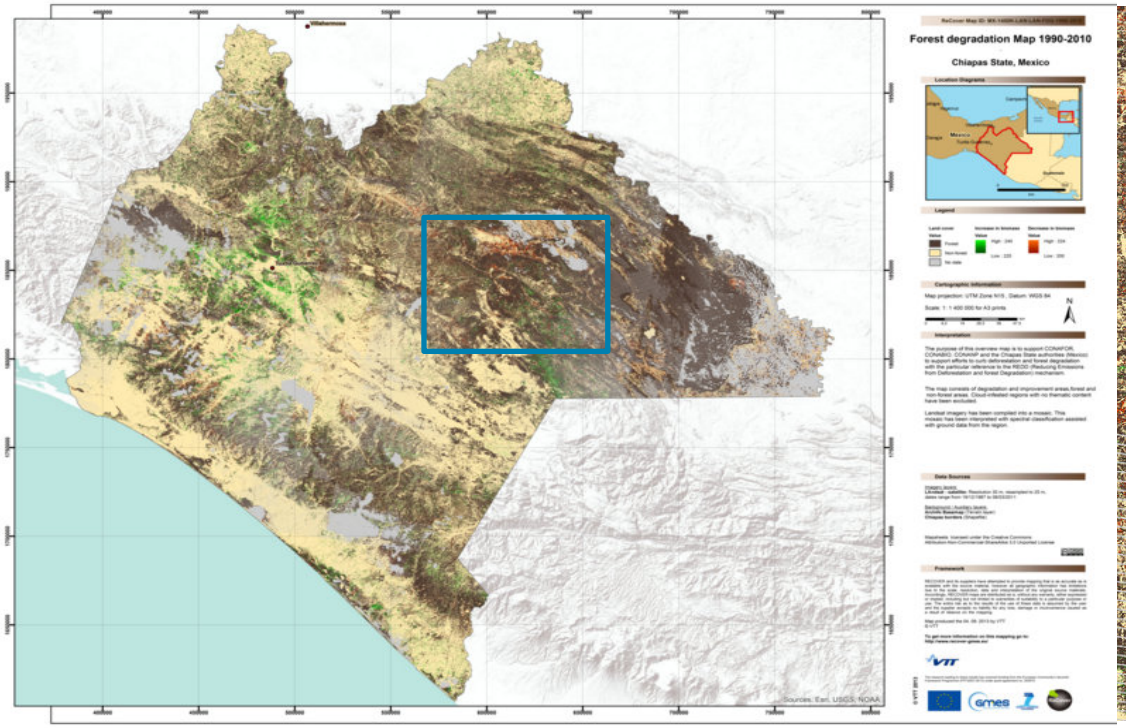
1990 2000 2010

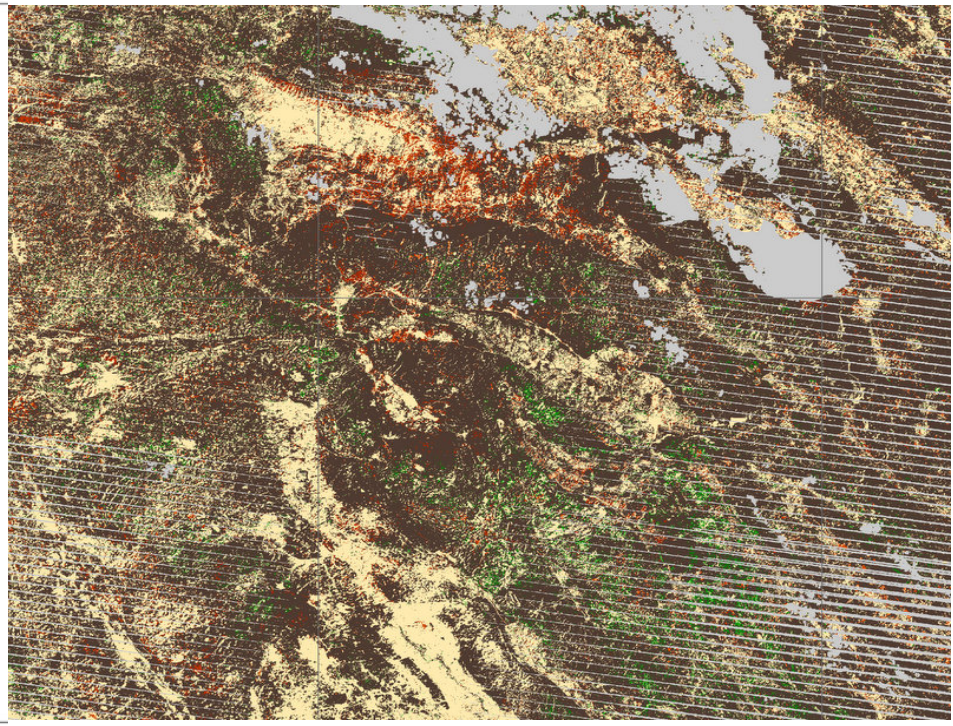
Area size ~ 11 km x 13 km

An algorithm to map degradation and recovery



Degradation & recovery 1990 - 2010

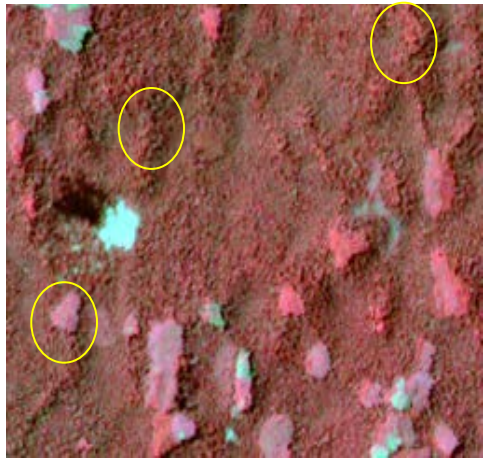




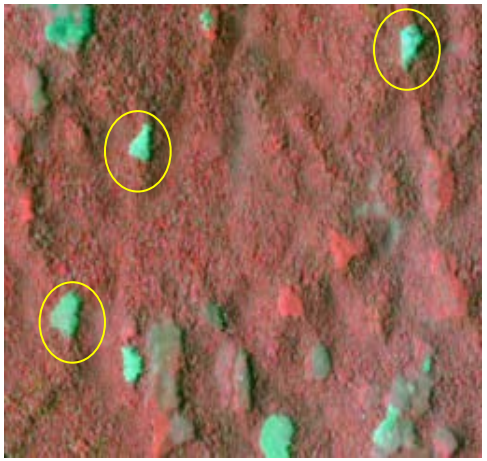
Chiapas, Mexico

Changes in Chiapas

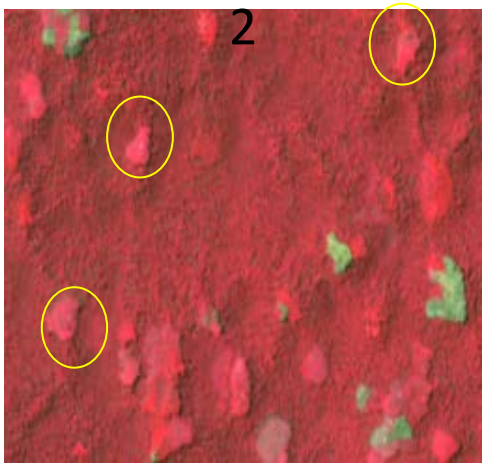
23.9.2014 Spot5



18.4.2015 Spot5



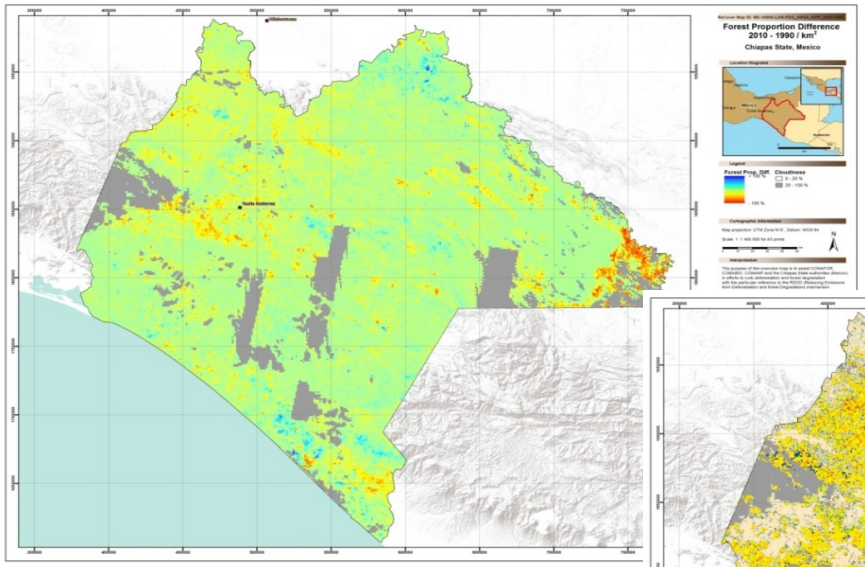
24.3.2016 Sentinel 2



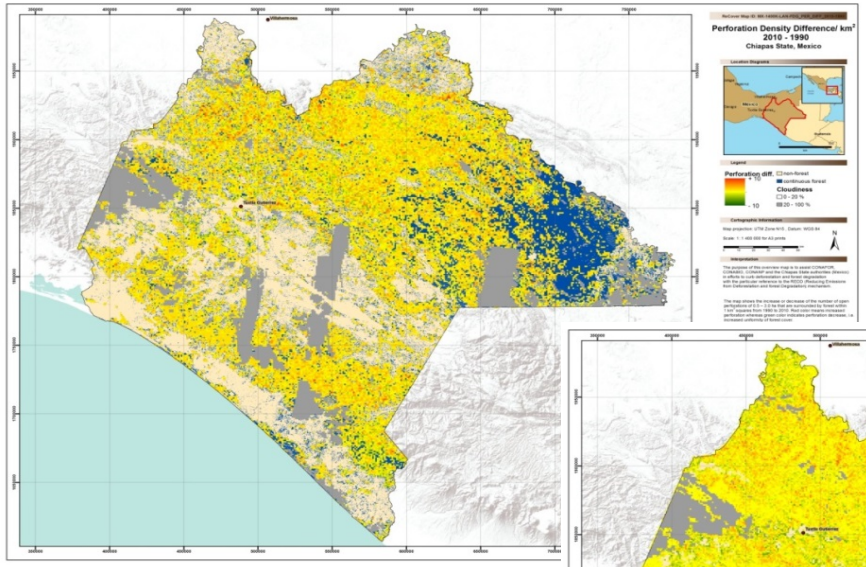
Google Earth, Mateo E. J. Tinajero

Google Earth, Yannick Meyer

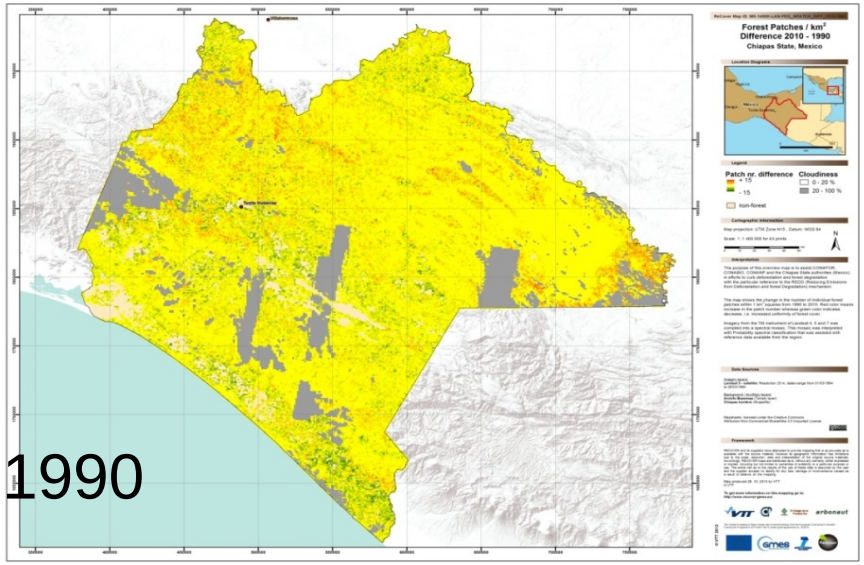
Structural parameter product examples – Landsat TM/ETM 1990, 2010



Forest proportion difference / km^2 2010-1990

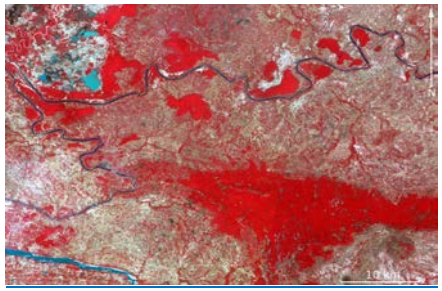


Perforation density difference / km^2 2010-1990

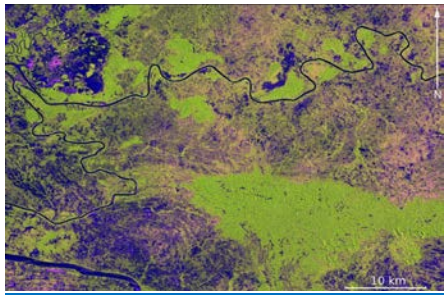


Forest patch number difference / km^2 2010-1990

Biomass predictions - Laos



(a)



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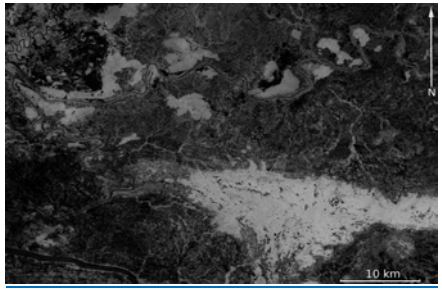

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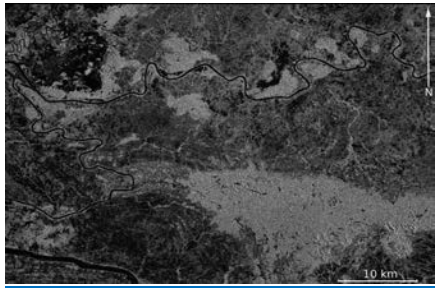

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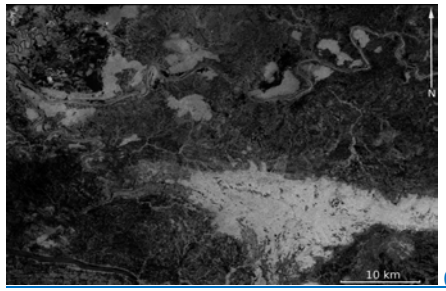

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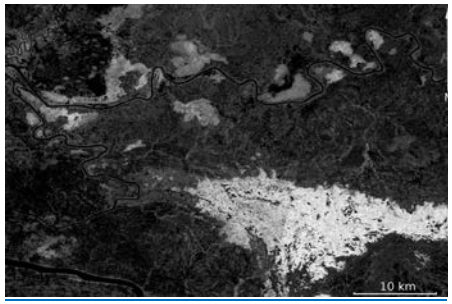

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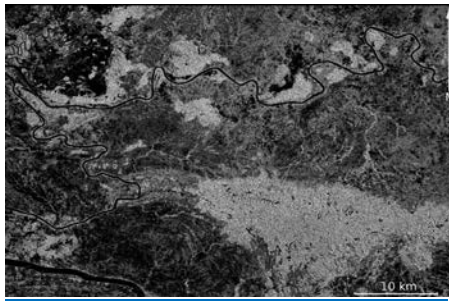
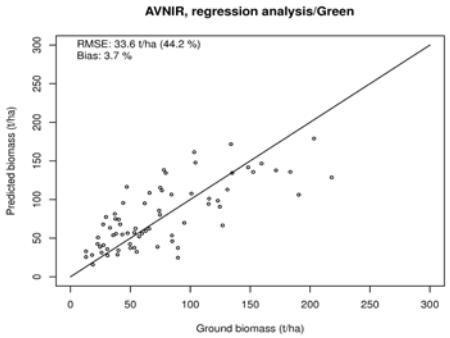
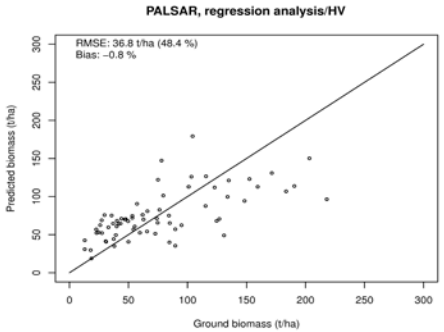


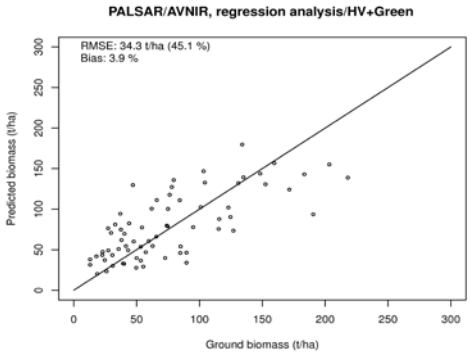
(g)



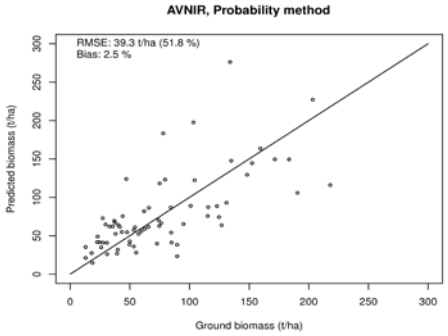
(a)



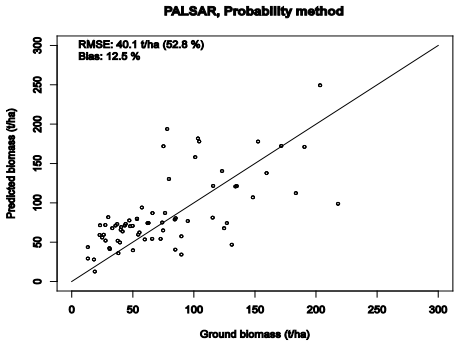
(b)



(c)



(d)

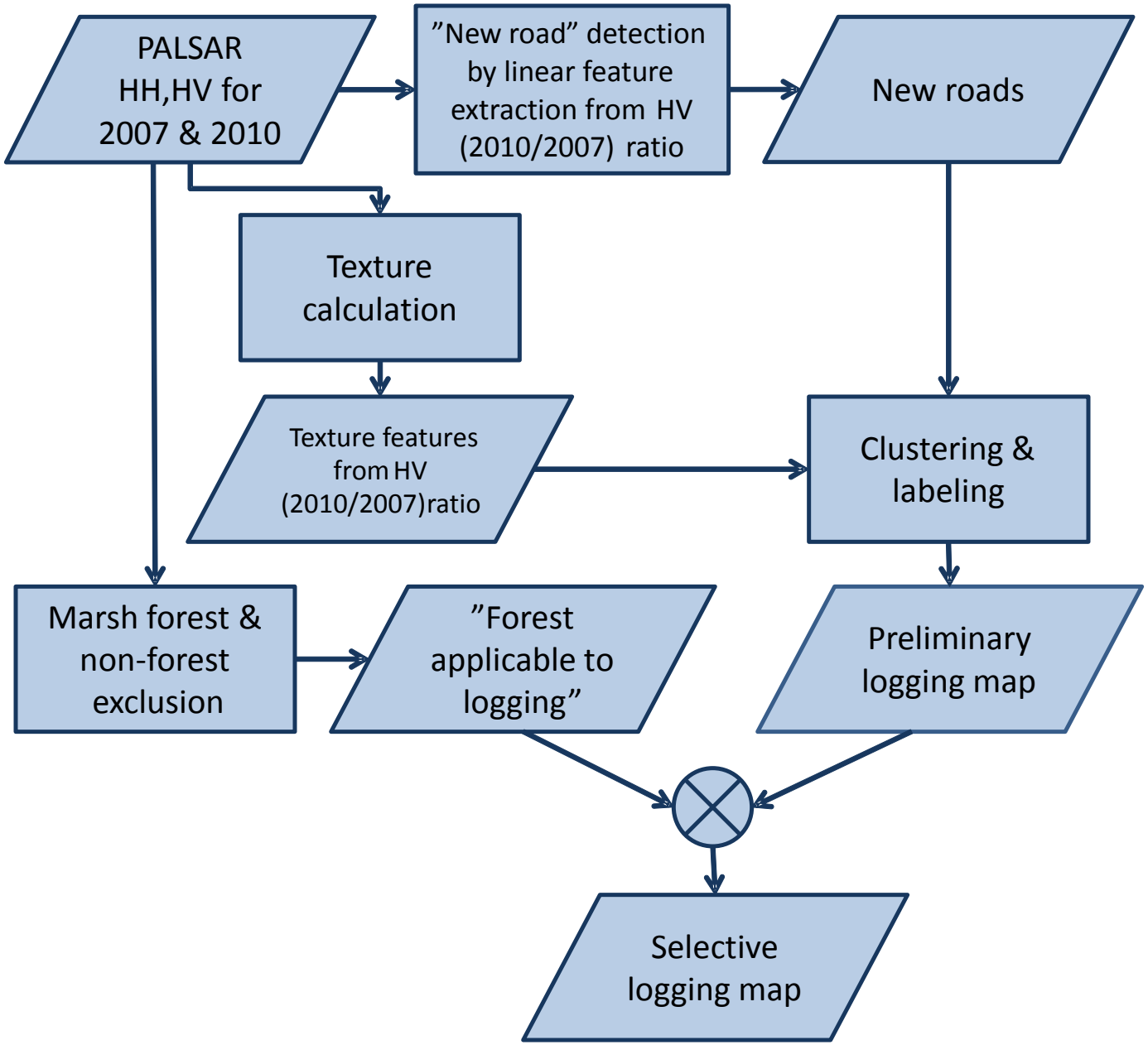


(e)

Fig. 6. Biomass estimates with ALOS AVNIR and ALOS PALSAR data: (a) AVNIR color infrared composite image, (b) PALSAR color composite image (HH red, HV green, HH/HV blue), (c) AVNIR regression prediction with green band only, (d) PALSAR regression prediction with HV only, (e) Green + HV regression prediction, (f) AVNIR Probability prediction, (g) PALSAR Probability prediction. Area size 60 km by 40 km. ALOS data ©JAXA.

Häme et al JSTARS 2013

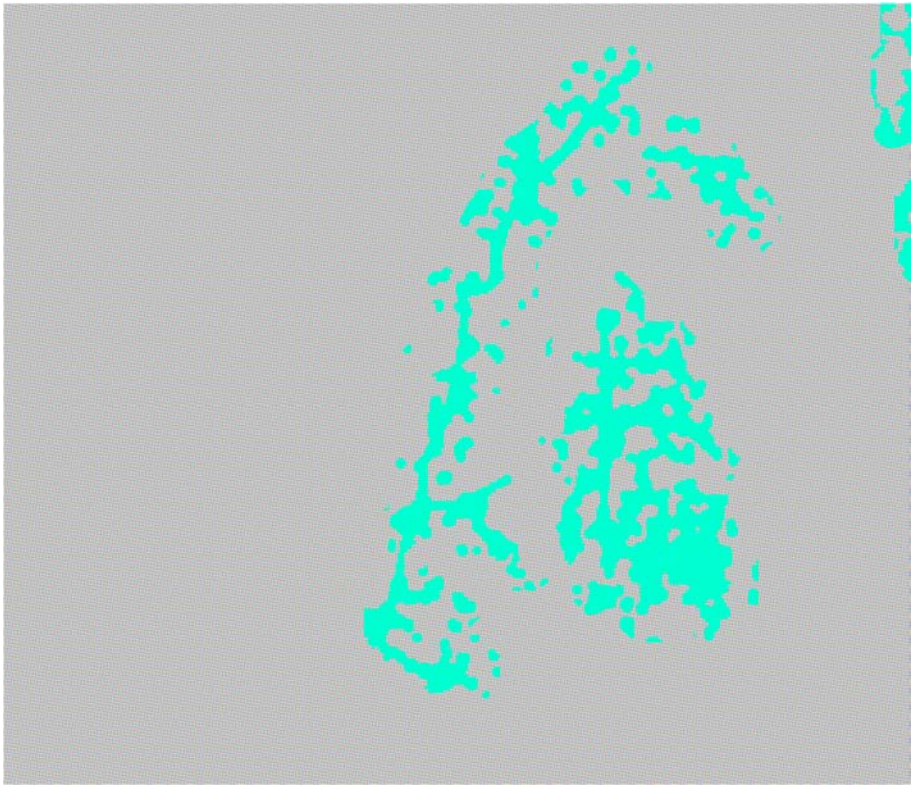
Algorithm for Mapping Selective Logging using SAR



Applied in Rep. of Congo

Rauste et al. ESA Living Planet 2013

Selective Logging in Republic of Congo/PALSAR Derived Map



- Roads on HV ratio (left) and logged area (right)

Work done in project ”GSE (GMES Service Elements) Forest Monitoring/REDD (Reducing of Emissions from Deforestation and forest Degradation in Developing Countries) Extension” coordinated by GAF AG (Germany) and funded by ESA

Accuracy Assessment of PALSAR-Derived Map

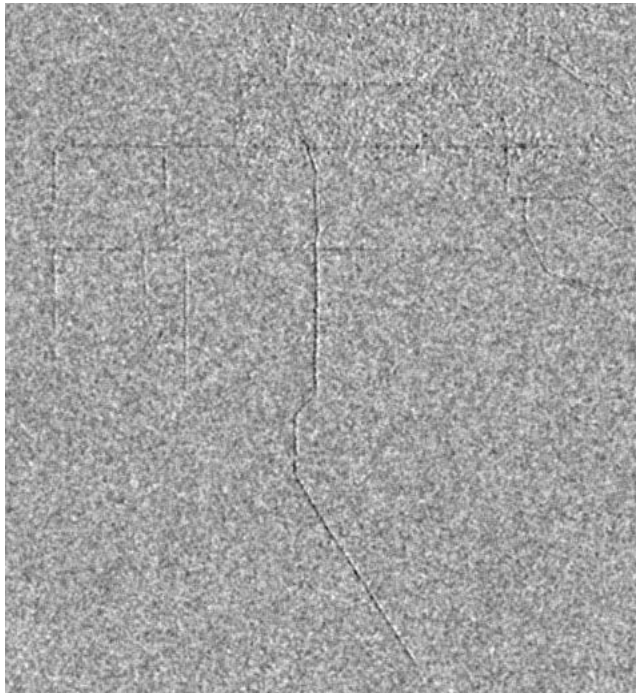
1st expert		Reference VHRO (GeoEye-1)			
		Other	Degraded forest	Total	User's accuracy
PALSAR	Other	58	85	143	40.6%
	Degraded forest	6	123	129	95.3%
	Total	64	208	272	
	Producer's accuracy	90.6%	59.1%		66.5%

2nd expert		Reference VHRO (GeoEye-1)			
		Other	Degraded forest	Total	User's accuracy
PALSAR	Other	80	63	143	55.9%
	Degraded forest	7	122	129	94.6%
	Total	87	185	272	
	Producer's accuracy	92.0%	66.0%		74.3%

RADARSAT-2 data

Disturbance by selective logging in 2012-2013 from RADARSAT-2 time series

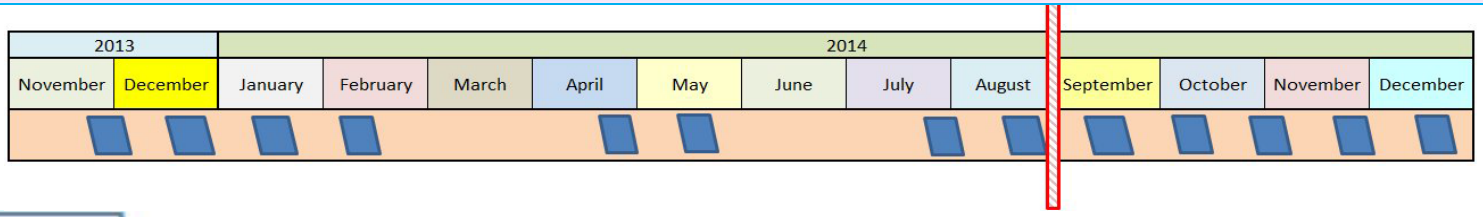
original data take acquired on 18.08.2013



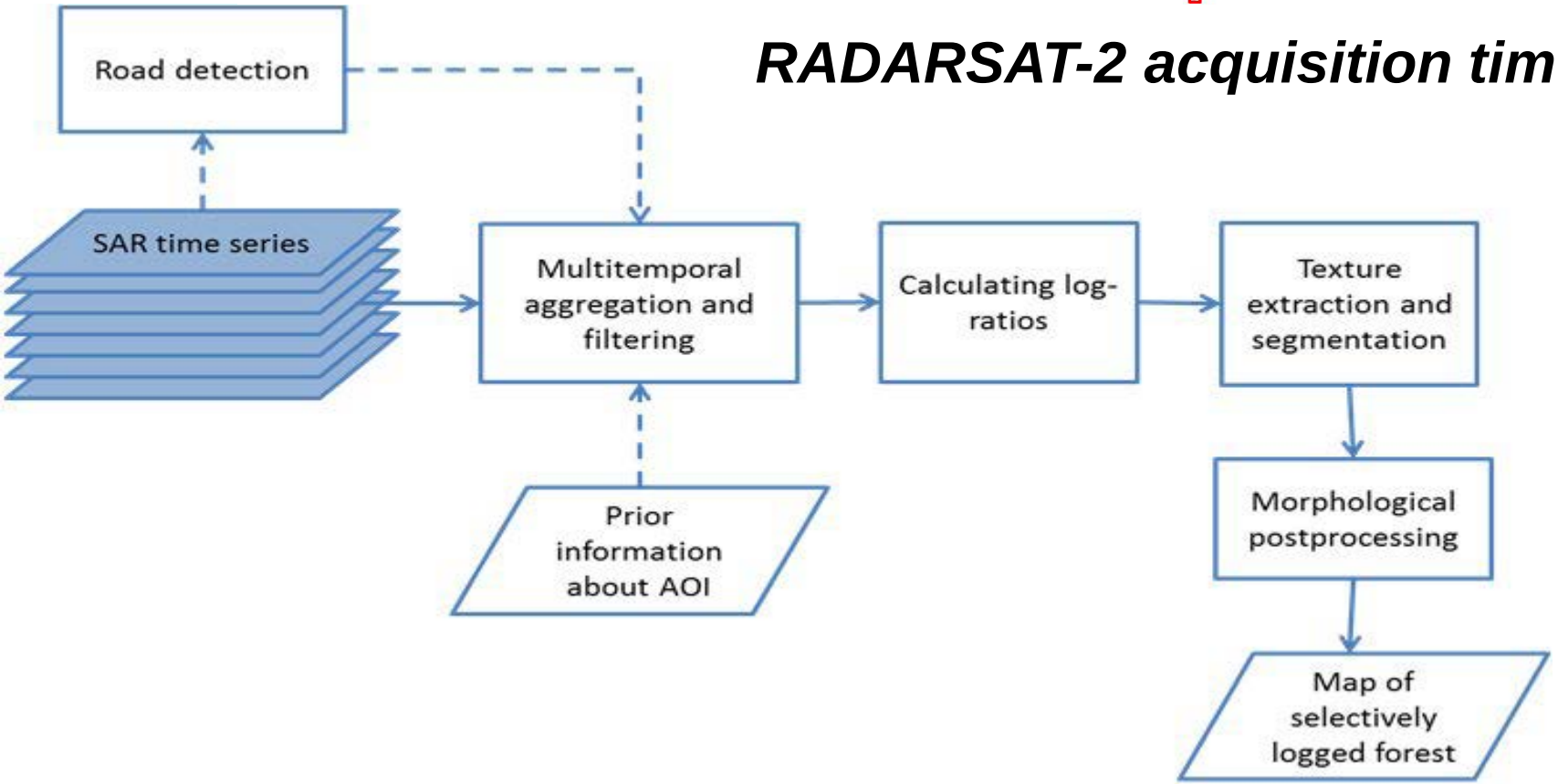
log-ratio image between 27.11.2012 and 22.11.2013;

RADARSAT-2 mapping methodology

Disturbance by selective logging in 2012-2013 from RADARSAT-2 time series

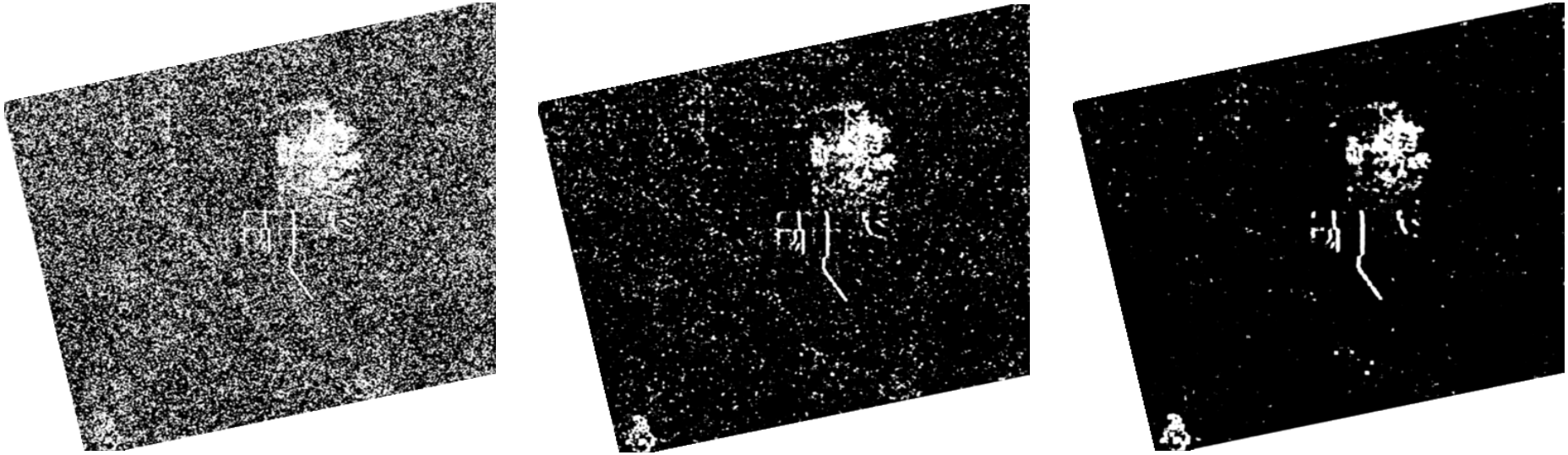


RADARSAT-2 acquisition timeline



Texture extraction

Disturbance by selective logging in 2012-2013 from RADARSAT-2 time series

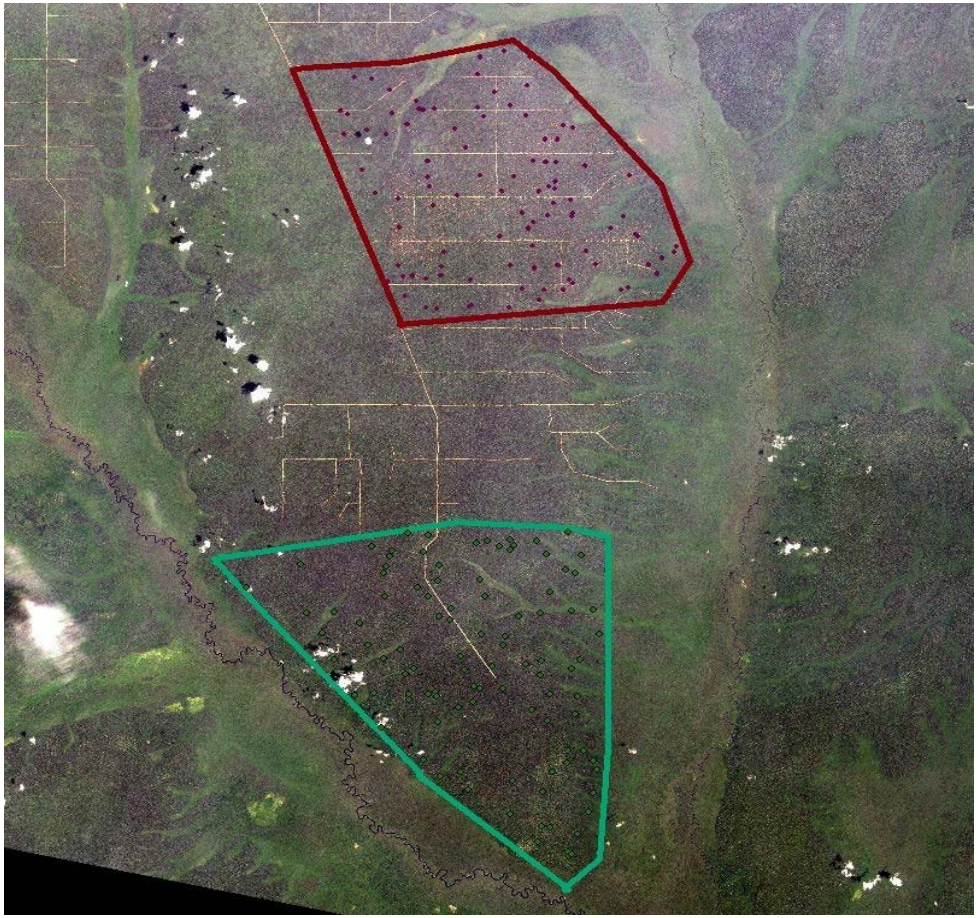


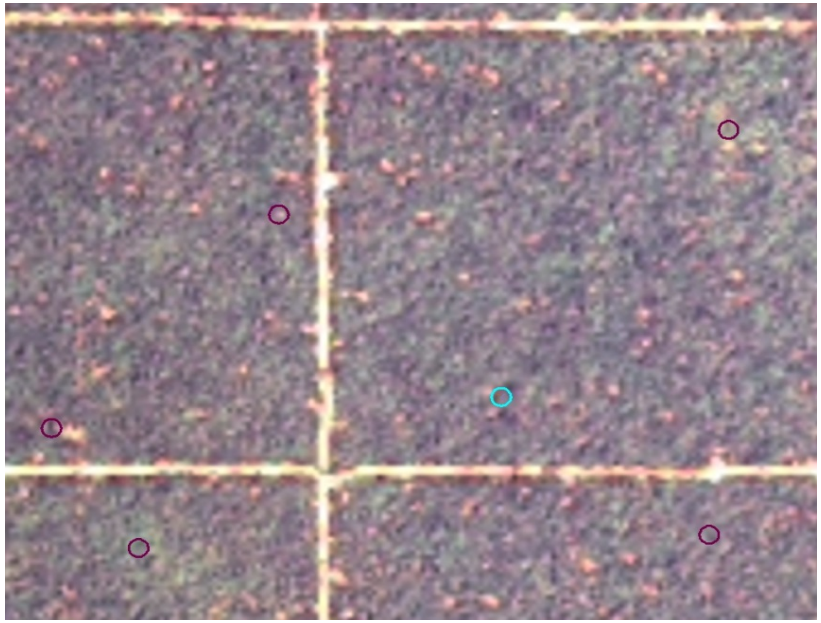
(A) (B) (C)

Window size: (A) 225 m; (B) 375 m; (C) 525 m

Accuracy assessment

Disturbance by selective logging in 2012-2013 from RADARSAT-2 time series

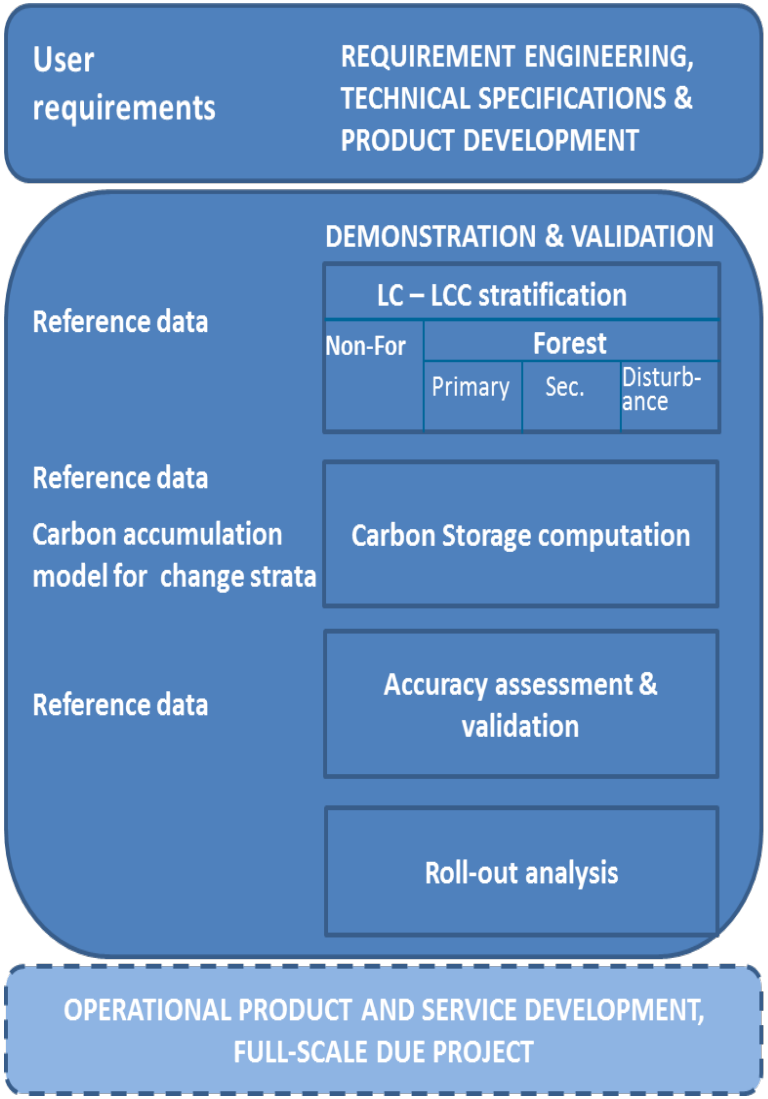




The overall accuracy was 96% in the area not affected by cutting, and 64 % in the area where selective logging was performed.

Lansat 8 scene with ground reference plots

Combining growth models and multi-date satellite imagery – ESA Innovator project Accucarbon



Combining growth models and multi-date satellite imagery – ESA Innovator project Accucarbon

$$\rho_c = \rho_s + (\rho_e - \rho_s)(1 - e^{-ft})$$

where

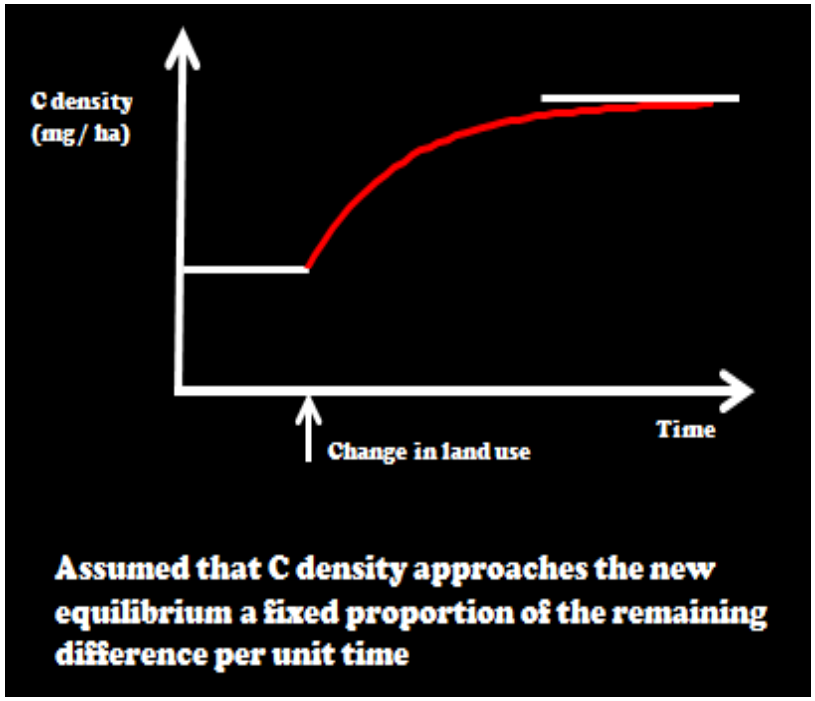
ρc is carbon density of the area unit

ρs is carbon density at start of the period of examination

ρe is equilibrium carbon density of the land use type in question

f is a parameter on transition speed.

Model by Larjavaara & Kanninen Univ. of Helsinki



Methods

2. Describe your satellite data requirements – optical

- Sentinel-2 ideal for wall to wall mapping of forest cover
- For the accuracy assessment of land cover variables one-meter or finer resolution required – statistical sampling
- Acquisition frequency bi-annual in humid tropics because of rapid vegetative succession

Details of Sentinel-2 and Landsat 8 images from August 20, 2015 from Southern Finland.

Area size 2.5 km x 2.5 km

Methods

2. Describe your satellite data requirements – radar

- Sentinel-1 or other C-band challenging – can be used for stratification
- L-band good potential in land cover mapping with reservations – 20 m multi-look resolution required
- With L-band potential for biomass similar to optical data with backscattering data
- Forest height with single pass interferometry - to be seen
- Use in particular when optical data are not available
- P-band SAR interesting but experimental with many restrictions (e.g. space object tracking radars, spatial resolution, ionosphere)

Methods

3. What is your approach to calibration and validation of product

- Multisource data by combining sample and wall-to-wall as described above
- Independent data for the accuracy assessment

Methods

4. Indicate the operational status of the existing technology (R&D, pre-operational, operational)

- Nothing really is operational?
  - No market
  - No standards for
    - Variable definitions (degradation in particular)
    - Products
    - Methods – optical pre-operational; radar R&D
    - Accuracy assessment procedures
  - No routine service provision and providers

Technical challenges

1. Describe the obstacles to operational use
   - Lack of market the main obstacle
2. Is ongoing access to data a concern?
   - To a lesser extent
     - L-band SAR; VHR optical – budgetary restrictions
3. Are the methods limited by a lack of automation or simplicity?
     - Yes – more automation is needed but not at a price of quality
     - Particularly in the radar domain methods for experts only
4. Are your IT/infrastructure needs met?
     - Improving – costs can be an issue
     - ESA's Forestry Thematic Exploitation Platform tries to respond to the infrastructure challenge

One-stop shop for forestry remote sensing services for the academic, operational public and commercial sectors

Contact

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In the photo, with permission: Daniel Vega / Universidad Juárez del Estado de Durango, a Forestry TEP pilot user

R&D requirements

1. Indicate the nature of the R&D required to advance the methods to operational use
   - the whole monitoring concept should be developed with strong statistical justification
   - radar methods unleashed to ordinary people
   - automation
   - standardization
2. What are the timelines for completing the R&D?
   - never complete – marked demand would (will?) enable operational services within 3 years
3. Describe your satellite data needs for R&D
   - Most important data types already available- costs an issue
   - Single pass L-band interferometric SAR would still be needed