



# Overview on satellite-based remote sensing methods to support REDD+

*Summary of the Literature Study DLR/BMWi FK 50EE1108*

## REDD Workshop

Bonn, 04.10.2012



Prof. Chr. Schmullius & Prof. B. Koch  
T. Theisel & C. Baumgart (FSU Jena) &  
Dr. Chr. Ueffing (FeLis Freiburg)





# Contents

- 1 REDD – Requirements to Remote Sensing
  - 2.1 Applications of Radar (and combinations)
  - 2.2 Applications of Optical & Lidar
- 3 Literature Database
- 4 Summary

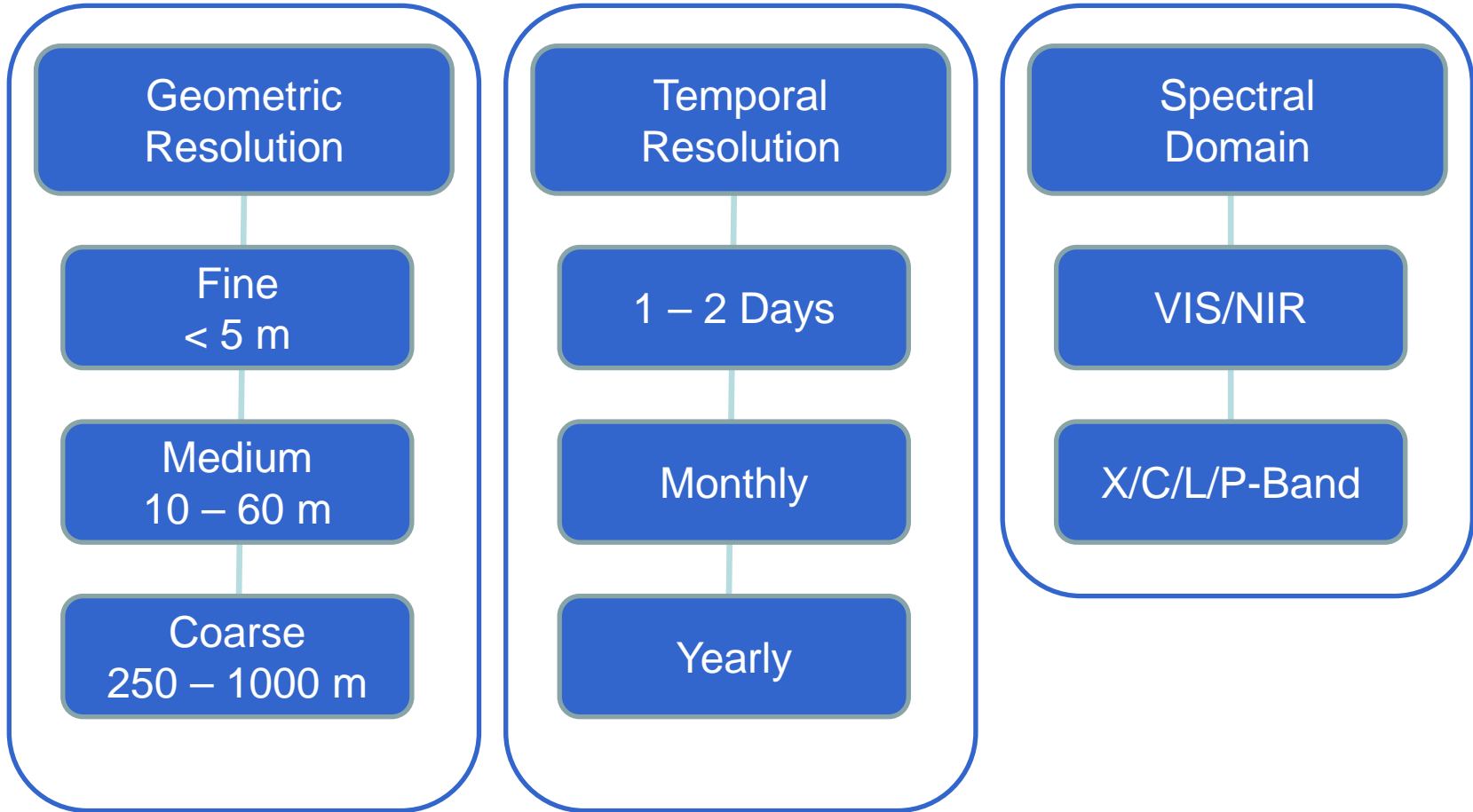


# 1 REDD – Requirements to Remote Sensing

- Consistency and continuity on different geometric scales:
  - national
  - sub-national/local
- Forest inventory as reference to change detection
- Robust, coherent and verifiable methods



# 1 REDD – Requirements to Remote Sensing





# 1 REDD – Requirements to Remote Sensing

## REDD-relevant Parameters:

- Special Emphasis on Geometric Resolution
  - Degradation:  $< 5$  m
  - Deforestation/Afforestation & Biomasse: 10 – 100 m
- Temporal Resolution
  - Minimum Yearly
  - High temporal variability of degradation processes
  - Trade-off: resolution vs. coverage
  - Cloud cover influences availability



## 2 Applications of Remote Sensing to REDD+

- **Literature Study**

- Analysis of scientific publications since 2000
- Focus on publications with sufficient reference and/or inventory data
- Special case radar applications:
  - Missing operational mapping systems
  - Publications mostly on the development of robust and automated methods (not operational applications yet)



## 2.1 Applications of Radar Data

- Focus on Satellite Data

Satellite	Wavelength
ALOS PALSAR	L-Band (quad)
ERS-1/2	C-Band (VV)
JERS-1	L-Band (HH)
Envisat ASAR	C-Band (quad)
COSMO-SkyMed-4	X-Band (quad)
Radarsat 1/2	C-Band (HH)/(quad)
TerraSAR-X/Tandem-X	X-Band (quad)



## 2.1 Applications of Radar Data

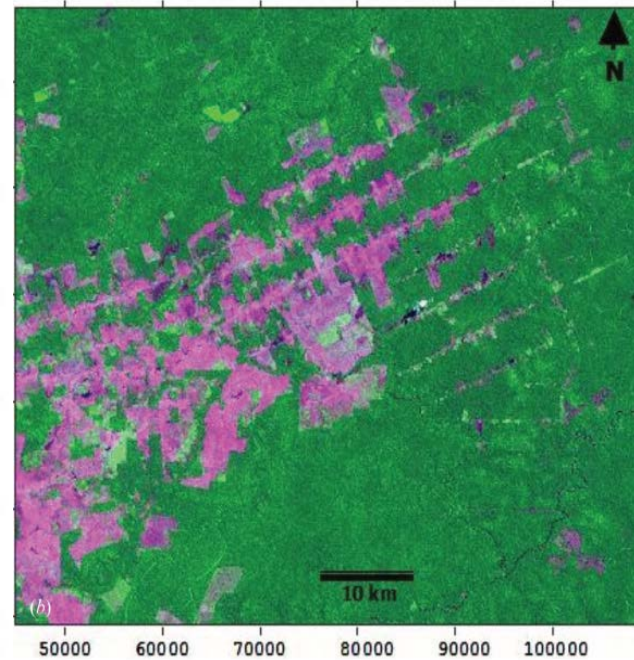
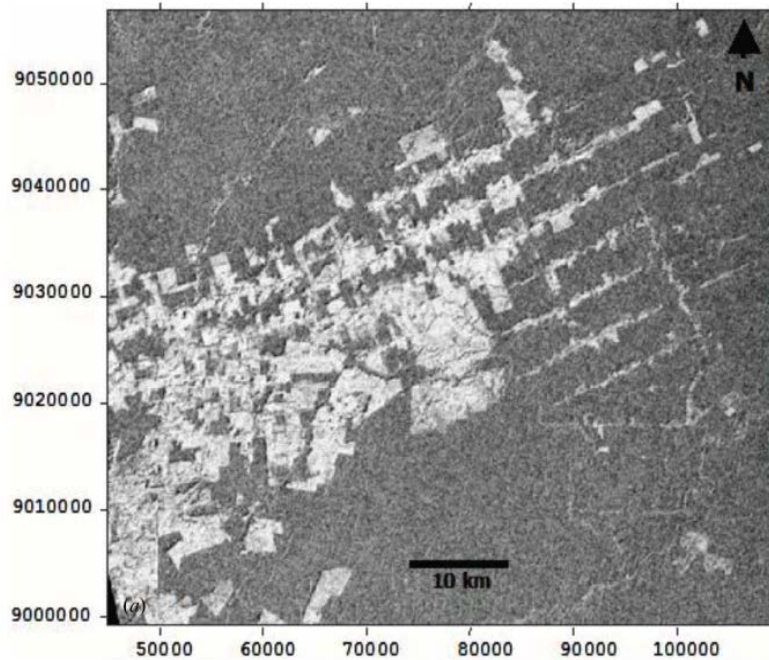
- Deforestation/Afforestation
  - Radar-Backscatter
  - Interferometric Coherence
  - Polarimetry
  - Combination with optical, mostly Landsat-data





- Almeida-Filho et al. (2009):
  - Simple Ratio Application

$$NDI = \frac{(HH - HV)}{(HH + HV)}$$





## 2.1 Applications of Radar Data

- **Degradation**

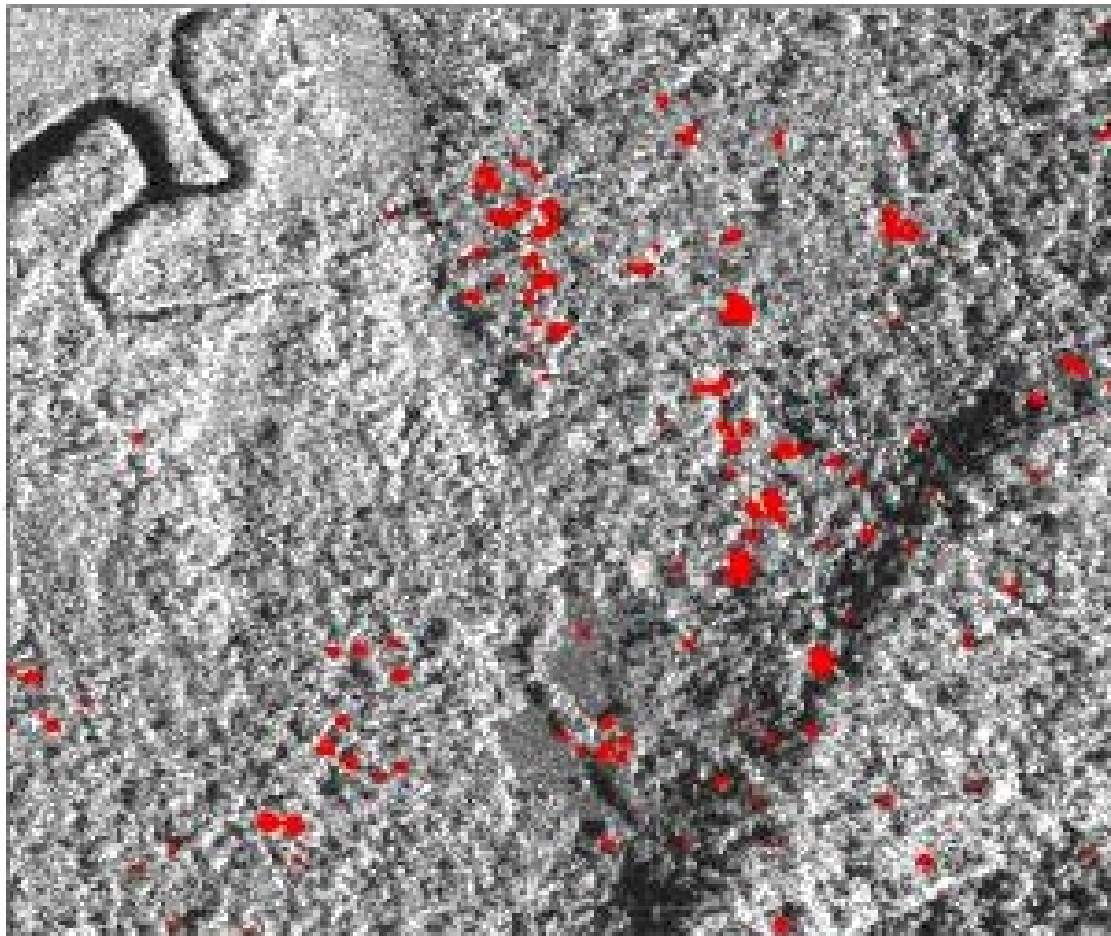
- Very few publications
- Resolution requirement  $< 5$  m

Kuntz et al. 2011

- multitemporale analysis of TerrSAR-X spotlight data
- hypothesis: decrease of intensities with reduced tree stands
- through der Intensitäten durch Abholzung



### Change Map - Tribuga, Colombia



#### TerraSAR-X spotlight Acquisition

Location of Basin Tribuga (Colombia)



Legend

■ Changes      — Tribuga-Fluss

#### Satellite Image Information

Acquisition date	09/02/2010
Acquisition time	10:47:00
Orbit altitude (km)	700
Resolution (m)	3.7 x 3.7
Polarization	HH/HH
Swath width (km)	18.5
Incidence angle	30.0°
Ground range resolution (m)	3.7
Range resolution (m)	3.7
Swath width (km)	18.5

Scale 1:400 000 000  
 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000  
 Meter

Copyright © 2010 TerraSAR-X  
 TerraSAR-X is a registered trademark of Airbus DS

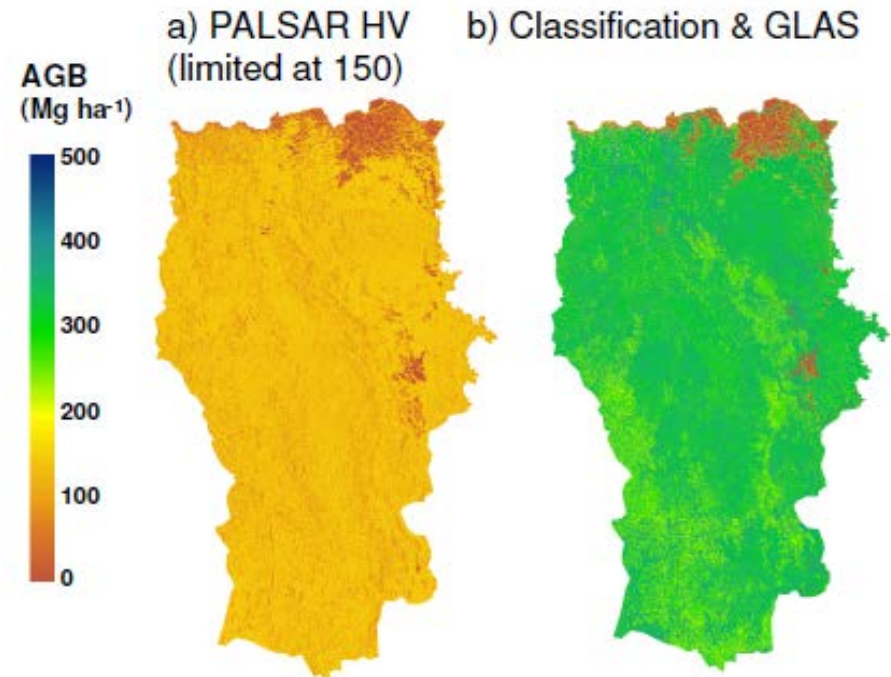




## 2.1 Applications of Radar Data

- **Biomasse**
  - Regression analysis using
    - intensity,
    - InSAR and
    - PolSAR-Data
  - Additional synergetic use of
    - inventory data,
    - optical data and
    - lidar

- Mitchard et al. (2011):
  - Synergy ALOS PALSAR and GLAS IceSAT
  - Classification of Tree Structure and Retrieval of AGB from Lidar-Data





## 2.2 Applications of optical & Lidar-Data

- **Airborne Systems (!)**
  - Aerial Photographs
  - LIDAR
- **Satelliteborne Systems**
  - Optical Sensors (e.g. Landsat, SPOT, IKONOS, QuickBird, ..)
  - LIDAR: IceSat/GLAS



## 2.2 Applications of optical & Lidar-Data

Sensor & resolution	Examples of current sensors	Minimum mapping unit (change)	Cost for data acquisition <sup>8</sup>	Utility for forest cover monitoring
Coarse (250-1000 m)	SPOT-VGT (1998- ) Terra-MODIS (2000-) Envisat-MERIS (2004-)	~ 100 ha ~ 10-20 ha	Low or free	Consistent pan-tropical annual monitoring to identify large clearings and locate “hotspots” for further analysis with mid resolution
Medium (10-60 m)	Landsat TM or ETM+, SPOT HRV IRS AWiFs or LISS CBERS HRCCD	0.5 - 5 ha	<\$0.001/km <sup>2</sup> for historical data \$0.02/km <sup>2</sup> to \$0.5/km <sup>2</sup> for recent data	Primary tool to map deforestation and estimate area change
Fine (<5 m)	IKONOS QuickBird Aerial photos	< 0.1 ha	High to very high \$2 -30 /km <sup>2</sup>	Validation of results from coarser resolution analysis, and training of algorithms



## 2.2 Applications of optical & Lidar-Data

- **Deforestation/Afforestation**
  - Synergistic exploitation of airborne and satellite-borne data sets
  - Methods are widely being applied
  - VHR and airphotos are being used for validation
  - Automated methods are being developed for use by non-experts





## 2.2 Applications of optical & Lidar-Data

- **Degradation**
  - Similar methods as for de-/afforestation
  - Great difficulties where degradation is not changing the top canopy structure
  - Temporal resolution not sufficient
  - Very small scale changes by medium resolution not detectable
  - Combination with LIDAR promising
  - Better spatio-temporal and radiometric resolution needed



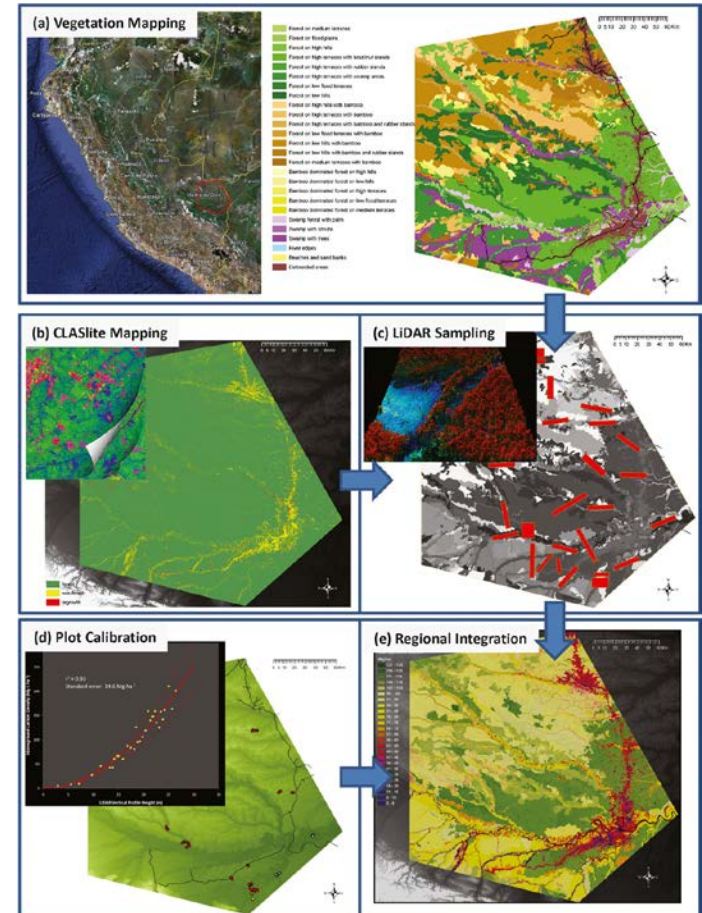
## 2.2 Applications of optical & Lidar-Data

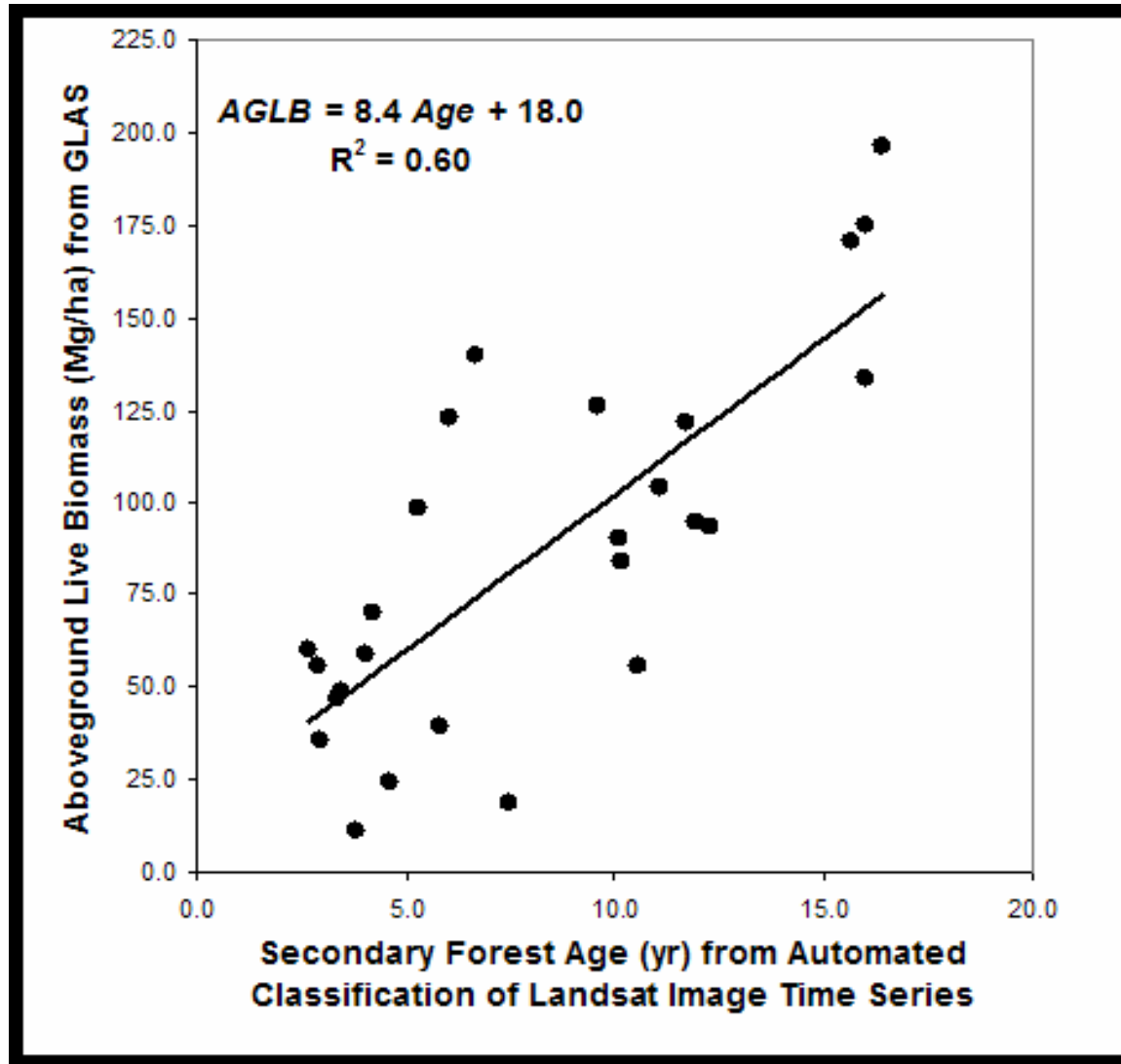
- **Biomasse**
  - Correlation of satellite classifications with inventories
  - Correlation of satellite classifications with airborne LIDAR-Data and inventories
  - Correlation of satellite classifications with (ICESat/GLAS) and inventories
  - Correlation airphotos with satellite data, airborne LIDAR and inventories



- CLASSlite and airborne LIDAR-Data (ALS) - ASNER (2009a), ASNER et al. (2010)

- Befliegung von min. 1% der Fläche mit ALS
- Kalibrierung der 3D-Strukturdaten des ALS durch eine eingeschränkte Anzahl von Felderhebungsdaten
- Erstellung von Biomassekarten mit 0,1 ha Auflösung





(HELMER et al. (2009))



Gruppen x REDD\_DLR.bib\*

- Alle Einträge
  - Masstab
    - kleinmasstäblich
    - mittelmassstäblich
    - grossmasstäblich
  - Region
    - Afrika
    - Asien
    - Australien/Ozeanien
    - Europa
    - Mittelamerika
    - Nordamerika
    - Südamerika
    - pan-tropisch
    - global
  - eingesetzte Sensoren
    - hyperspectral
    - Lidar
    - multisensoral
    - Optische Sensoren
    - Radar
  - Parameter
    - biomass
    - deforestation
    - degradation
    - forestation
  - Type\_of\_article
    - Methodenbeschreibung
    - Projektbericht
    - Softwarebeschreibung
    - Übersichtsartikel
  - Methode
    - Interferometrie
    - Intensitätsanalyse
      - Polarimetrie
    - Bildinterpretation
- Einstellungen

#	Entrytype	Author	Title	Year	Journal	Sensor	Bibtexkey
1	Article	Asner et al.	Automated mapping of tropical deforestation and forest degradation: CL...	2009	Journal of Applie...	Landsat TM, Landsat ETM+, Spot 5...	Asner2009
2	Article	Cochrane	Fire science for rainforests	2003	Nature		Cochrane2003
3	Article	Engelhart et al.	Aboveground biomass retrieval in tropical forests - The potential of co...	2011	Remote Sensin...	TerraSAR-X, ALOS PALSAR	Engelhart2011
4	Article	Koch	Status and future of laser scanning, synthetic aperture radar and hypers...	2010	ISPRS Journal o...		Koch2010
5	Article	Mitchard et al.	Measuring biomass changes due to woody encroachment anddeforest...	2011	Remote Sensin...	JERS-1, ALOS PALSAR, Quickbird	Mitchard2011
6	Article	Mitchard et al.	Using satellite radar backscatter to predict above-ground woodybiomas...	2009	Geophysical Re...	ALOS PALSAR, Landsat ETM+	Mitchard2009
7	Article	Morel et al.	Estimating aboveground biomass in forest and oil palm plantation in S...	2011	Forest Ecology a...	ALOS PALSAR	Morel2011
8	Article	Saatchi et al.	Impact of spatial variability of tropical forest structure on radar estimatio...	2011	Remote Sensin...	AIRSAR, Quickbird	Saatchi2011
9	Article	Santos et al.	Airborne P-band SAR applied to the aboveground biomass studies in th...	2003	Remote Sensin...	AeS-1 (AeroSensing SAR System)...	Santos2003
10	Article	Schmidke et al.	Das Projekt neue Bestandeskarte	2011	Schweizerische ...	Luftbild	Schmidke2011
11	Article	Siegert and Hoffmann	The 1998 Forest Fires in East Kalimantan(Indonesia): A Quantitative Ev...	2000	Remote Sensin...	NOAA AVHRR, ERS-2	Siegert2000a
12	Article	Siegert and Ruecker	Use of multitemporal ERS-2 SAR images for identification of burned sc...	2000	International Jou...	ERS-2	Siegert2000b
13	Conference	Nakayama and Siegert	Comparative study on C and L band SAR for fire scare monitoring	2001		JERS-1, ERS-2, Landsat TM	Nakayama2001
14	Sensor					Landsat TM	Landsat_TM

### Article (Asner2009)

Asner, G. P.; Knapp, D. E.; Balaji, A. & Páez-Acosta, G.  
Automated mapping of tropical deforestation and forest degradation: CLASlite  
*Journal of Applied Remote Sensing*, 2009, 3, 1-11

**Abstract:** Monitoring deforestation and forest degradation is central to assessing changes in carbon storage, biodiversity, and many other ecological processes in tropical regions. Satellite remote sensing is the most accurate and cost-effective way to monitor changes in forest cover and degradation over large geographic areas, but the tools and methods have been highly manual and time consuming, often requiring expert knowledge. We present a new user-friendly, fully automated system called CLASlite, which provides desktop mapping of forest cover, deforestation and forest disturbance using advanced atmospheric correction and spectral signal processing approaches with Landsat, SPOT, and many other satellite sensors. CLASlite runs on a standard Windows-based computer, and can map more than 10,000 km<sup>2</sup>, at 30 m spatial resolution, of forest area per hour of processing time. Outputs from CLASlite include maps of the percentage of live and dead vegetation cover, bare soils and other substrates, along with quantitative measures of uncertainty in each image pixel. These maps are then interpreted in terms of forest cover, deforestation and forest disturbance using automated decision trees. CLASlite output images can be directly input to other remote sensing programs, geographic information systems (GIS), Google EarthTM, or other visualization systems. Here we provide a detailed description of the CLASlite approach with example results for deforestation and forest degradation scenarios in Brazil, Peru, and other tropical forest sites worldwide.





# 4 Summary

Friedrich-Schiller-Universität Jena



- Very dynamic application field due to upcoming sensors
- Increasing development of expert systems for non remote sensing users
- Explosion of applications in the field of airborne LIDAR-Systems
- Decreasing costs for (some) data sets
- NEEDS:
  - Methods in heavily relieved terrain
  - Methods for degradation monitoring
  - More synergetic applications including radar

*...and a personal wish: Spaceborne LiDAR and PolInSAR L-band*