Reducing Emissions from Deforestation and Degradation in AFrica & K&C Initiatives

Direct biomass assessment using ALOS-PALSAR in Cameroon

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REDD Pilot in Cameroon identified challenges in using remote sensing for forest monitoring in the Congo region:

- the frequent cloud cover in the region which hampers the use of the optical data
- the need to use of multi-scale and multi-sensor data for forest monitoring
- no operational methodologies for degradation assessment and mapping
- no operational methods for the use of remote sensing for direct biomass assessment and mapping
Study Sites - Cameroon

Study Site 1: Biomass Assessment and Forest Degradation Mapping

- Availability of in situ biomass information.
Study Sites - Cameroon

Study Site 2: Forest Cover Change Mapping

- Filling gaps with supplementary optical and radar data

Thuy Le Toan, SDS 3-Geo FCT, Tanzania, 6-10 Feb 2012
Study site 3: Direct EO biomass assessment

Adamawa test area: interface between humid forest and savanna

Deciduous shrubland with sparse trees

Mosaic of forest-savanna

Evergreen low land forest
Forest-savanna ecosystem

• An important ecosystem in Cameroon:
  – 5.9 M ha forest-savanna mosaic
  – 4.5 M ha forest-agriculture mosaic
• No carbon inventory (Cerruti et al., 2008)
• Prone to lost of carbon at forest edges in populated rural area
• Potential of SAR data to estimate biomass and to detect changes

Motivation for demonstration study on biomass mapping and biomass change detection using ALOS-PALSAR of 2007 to 2010.
• The study area in the Adamawa region covers 14700 km$^2$ in central Cameroon, including the Mbam Djerem National Park, the Pangar Djerem Reserve in the South and lake Mbakaou in the North. The region extends from humid forests contiguous with the Congo basin tropical forest belt in the south to savanna with narrow gallery forests in the North. The landscape is a mosaic of forest types, with forest penetrating into the savanna as gallery forests, and also as forest patches on plateaus.

• The area was subject of a recent study (Mitchard et al., 2011), in which biomass changes from 1997 to 2007 have been assessed and mapped at a resolution of 500 m.

• In this project, methods are developed for biomass mapping at a resolution of 25 m for 2007, 2008, 2009 and 2010 using ALOS-PALSAR data.
Objective of the study

- Develop and refine methodologies/algorithms for direct biomass assessment in forest-savanna ecosystem using EO data.
  - Primary study site: the Adamawa Cameroon test site (1.5 M ha). Further validation/testing in Central African Republic
  - Primary EO data: ALOS-PALSAR. Further stages: combination PALSAR with HR optical and SAR data.

- Science questions
  - Improving information extraction from L-band SAR by reducing the effect of SAR system and environment on the radiometric variation of the data,
  - Improving biomass extraction using multi sensor data
Tasks to be performed

• Develop a processing chain using mostly free software
• Apply to the study region
• Define the insitu measurements for calibration/verification
• Refine the method with training plots
• Verification the results with validation plots
  - Increase the number of validation plots by collaboration (University of Yaounde, CIRAD, RAINFOR)
• Refine software and training

Expected outcomes: products useful for REDD knowledge transfer
**Study site**

Tibati: main closest city  
Ngaoundere: closest meteo data

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**EO data collection**

38 PALSAR dataset acquired from 2007/26/07 to 2010/12/14  
28 FBD  
10 PLR

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Data processing flowchart

- Includes research components
- to be simplified after testing/validation
- based on in-house and free software for wider implementation
Processing chain adaptation

Shift of ≈ 3db → radiometric calibration needed

Calibration developed:

\[ |S_{XY}|^2_{i,corrected} = a_i \cdot |S_{XY}|^2_i + b \cdot \]

\[ i = \{1, \ldots, n\} \quad [a_i, b_i] \subset \mathbb{R}^2 \]
Coverage of ALOS polarimetric data
Mapping of forest ecosystems

Discrimination of high/low biomass by scattering mechanisms (polarimetry)

Forest: more volume and double bounce scattering than non forest
Adamawa site
Mosaic of polarimetric PALSAR data

HH+VV: B
HH-VV: R
HV : G

Gallery forest
Forest-Savanna

Dense humid forest
Enhancing forest/non forest discrimination

HH+VV: B
HH-VV: R
HV: G
Model used for preliminary biomass retrieval

Biomass retrieval models developed by CESBIO using L-band HV intensity

- Derived from forest backscatter modelling
- Calibrated at test forest in Vietnam (JAXA-KC project)
- Needs (few) training plots to account for variability of ecosystems and for PALSAR data radiometric quality

To be refined by field data in Cameroon

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Preliminary biomass maps

~120 km x 120 km

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Preliminary biomass maps
Preliminary assessment

- 60-80 t/ha
- 80-100 t/ha

Mbam and Djerem National Park

Thuy Le Toan, SDS 3-Geo FCT, Tanzania, 6-10 Feb 2012

Coordinated by
In situ ground data collection

In situ plot size requirement:

- At least 1 ha in tropical forest for natural variability
- At least 1 ha for radar validation because of speckle effect

- Existing plots are not adapted

Effect of plot size, tropical forest

\[
CV_{total} = \left( CV_{allom}^2 + \frac{b^2}{A} \right)^{1/2}
\]

Chave, 2011

0.25 ha
1 ha
2 ha
4 ha

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In situ ground data collection

- Campaign from 15 January to 5 March 2012 by Mesa-Consult
- CESBIO team(3): 18-28 January for plot selection
- ND, MINEPDED, MINFOR representatives involved

- 21 plots
- Plot size: 1 ha,
- Geolocation accuracy (max of 10 meters)
- Plot parameters: species composition, forest structure, understory conditions, average biomass and error from biomass distribution
- Individual tree measurements (biomass, tree height, allometric equation, DBH, wood density and basal area)
- Ancillary data (soil type, slope, elevation, climate data, management)
In situ verification of the preliminary map

Burnt areas

Jun 2010

23 Jan 2012

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In situ verification of the preliminary

Gallery forest
In situ verification of the preliminary map

High biomass patch

Coordinated by GAFAG
In situ plot data collection

Number of plots

| 2 | 3 | 3 | 4 | 4 | 3 | 2 |

1 ha plot

Allometry (Chave et al. 2005) will be used:

**Dry forests:** \( AGB = \exp\{-2.187+0.916\ln(RD^2H)\} \equiv 0.112 \times (RD^2H)^{0.916} \)

**Moist forests:** \( AGB = \exp\{-2.977 + \ln (RD^2H)\} \equiv 0.0509 \times RD^2H \)

Where D: dbh [cm]; R: wood specific gravity [g/cm³], H: height [m]

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Field work  January 2012

DBH measurements
Change in forest biomass

No visible change in this less populated area

July 26, 2007 (left) June 18, 2010 (right). The area (15 km x 17 km) is on the East part of the Mbam and Djere National Park.
Change of biomass in the Pangar Djerem Reserve at the edges of the forest:
Observed changes to be interpreted:
- seasonal vegetation?
- forest edges degradation?

Interpretation will be done using optical data
Summary

• Preliminary results obtained for biomass assessment in VS 3 in Cameroon
• Works to be done to improve the method and to assess the results as a ‘REDD useful’ information source
  – Above ground carbon and accuracy in forest-savanna ecosystem
  – Assess and interpret changes in biomass, and accuracy
  – More research on high biomass forest: combining with HR data
• Processing chain for forest monitoring using radar data developed to be user-friendly for pre-operational implementation