Biomass mapping: Potential of texture analysis on optical very high spatial resolution canopy images

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And the Forafama project consortium

‘ Land cover changes and forest biomass in Central Africa ‘
March 20-21, 2014, Libreville, Gabon
Mapping forest structure and A-G biomass

• Field plots:
  ▪ Biomass approached via indirect estimates (DBH)
  ▪ Limited representativity (costs)
  ▪ Limitations wrt variation at different scales

• Pixelwise analyses:
  ▪ Saturation for intermediate biomass levels: optical indices, also radar

• Airborne LiDAR:
  ▪ Cost

• Opportunity:
  ▪ Increased availability of very high spatial resolution (VHSR) – pixel < ou ~ 1 m, optical imagery
Using VHSR canopy optical images?

• Where is AGB mostly located in a rain forest?
  ➢ trunks of large individuals

• What is most likely to be correlated to wood stock?
  ➢ crown sizes, tree heights.
  ➢ NOT: fPAR, mean reflectance, NDVI, etc.

• Availability of VHSR spaceborne imagery
  ➢ Ikonos, GeoEye, Pleiades, SPOT6-7, etc.) – Archives, GoogleE.

• Operational methodologies to be tested
  ➢ characterization of canopy texture (eq. to visual photo-interpretation)
  ➢ Relating texture indices to quantify forest structure and AGB (even for saturating conditions)
Quantifying canopy image texture: the FOTO method

2D Fourier spectra

« radial » spectrum

Dominant frequencies

Senescent
Mature
Adult
Young
Pionnier

Peaks at dominant frequencies

100 m

French Guiana, mangroves

Proisy et al. RSE (2007)
Canopy texture analysis: the FOTO method

Logging concession

Local maps of biomass:
- 100 – 1,000 km²
- RMSE ~ 15-20%
- No saturation
- Fr. Guiana: Proisy et al. (2007), RSE
- India: Ploton et al. (2012), Ecol Appl

From N. Barbier, unpubl.
Effect of image acquisition conditions (scene geometry)

Santarem, Brazil

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Combining images in ‘forward’ configuration for diachronic and/or regional studies

Santarem, Brazil (diachronic)

Central Africa

Ikonos vs GeoEye (+10 years interval)

No bias in the main FOTO index (PCA1) for matching areas between images

N. Barbier, unpubl.
Stability of the textural information

(43) Korup (Cameroon), Ikonos 2003

Maps of the main FOTO index (PCA1)
Hot colors, coarse-grained canopy: here, large crowns (evergreen, closed canopy)
Towards a large scale calibration in Africa
Biomass calibration

Images

Samples in 3 countries

Including the main forest types:

- Mixed evergreen
- Evergreen monodominant
- Mixed evergreen/deciduous
- Open canopy with Marantaceae

Work in progress (more plots needed)

N. Barbier, unpubl.

All plots, $R^2=0.68843$ RMSE=51.8922

Predicted biomass vs. Biomass t DM/ha
Conclusion

• **Potential of VHSR optical images**
  - Canopy aspect information is relevant to predict stand structure variables (including AGB) via texture metrics
  - Effects of varying acquisition parameters can be controlled and even mitigated (to some extent)

• **Upscaling from stand to landscape**
  - Field -> airborne (lidar) -> **VHSR** -> High SR -> Moderate SR
  - Affordability as part of nested sampling

• **Prospects/ ongoing**
  - Better understanding of noise and bias via 3D stand/radiative transfer modelling
  - Calibrating and cross-validating for diverse African forests, but more data (plots + images) are needed
A matter of team and field work …

Thank you! Merci! -

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References


• Additional slides (backup)
RCA: GeoEye pansharpened G-NIR-B
Above-ground biomass prediction from FOTO canopy texture metrics

FG (mangrove), Proisy et al. (2007), RSE

DRC, Bastin et al. (2014), *Ecol. Appl. In review*
AGB prediction in the evergreen forests, Western Ghats of Karnataka (India)

Références:

AGB assessed from field plots, local allometry (t DM ha\(^{-1}\))

RMSE = 55 t DM ha\(^{-1}\) (< 15%)
AGB Mapping from Ikonos/Google Earth® images

- Western Ghats of Karnataka, India

Why does it work?

- Allometric relationships
- Dbh - AGB: main way of assessing AGB
- Dbh - Height: high variability
- Dbh – crown: seems more stable (?)

- Crown size distribution tells about dbhs of canopy trees and AGB

\[ a_{\text{can}} \propto \text{dbh}^{1.27} \]

India (WG)
Antin et al. 2013

Panama (BCI)

\[ a_{\text{can}} \propto \text{dbh}^{1.36} \]
Simulating canopy images

- Measures

3D stand models

Radiative transfer (DART)

Canopy images

• Measures

3D mockup (Stretch)

3D stand models
Mitigating instrumental bias

![Graphs showing PCA1 vs Dg (cm)](image)