

# Canopy textural properties from metric resolution imagery: Validation, sensitivity and perspectives within REDD.

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**IRD**



**COMIFAC Regional Workshop  
Monitoring Carbon Stocks and Fluxes in the Congo Basin  
2-4 February 2010  
Brazzaville, Republic of Congo**

# Programme Pilote de recherches: Biodiversité, Changements globaux et Santé dans les forêts tropicales humides

- Part of a broader effort from IRD in central Africa:
  - Tropical forest as a focal object for interdisciplinary research ;
  - Consequences of global change on biodiversity, resources and health;
  - Possibly set up permanent research platforms.

- Yaoundé workshop 10/2009

➤ Call for partnerships...



# Need to quantify canopy structure

- Valuable for :
  - Carbon dynamics and forest degradation assessment;
  - Forest ecology (allometry rules, gap dynamics, etc.);
  - Forest-climate interaction (gas and vapor exchange);
  - Forest types, etc.
- **Difficult to measure** in the field,
  - Approached via indirect estimates (DBH);
  - Limited representativity.

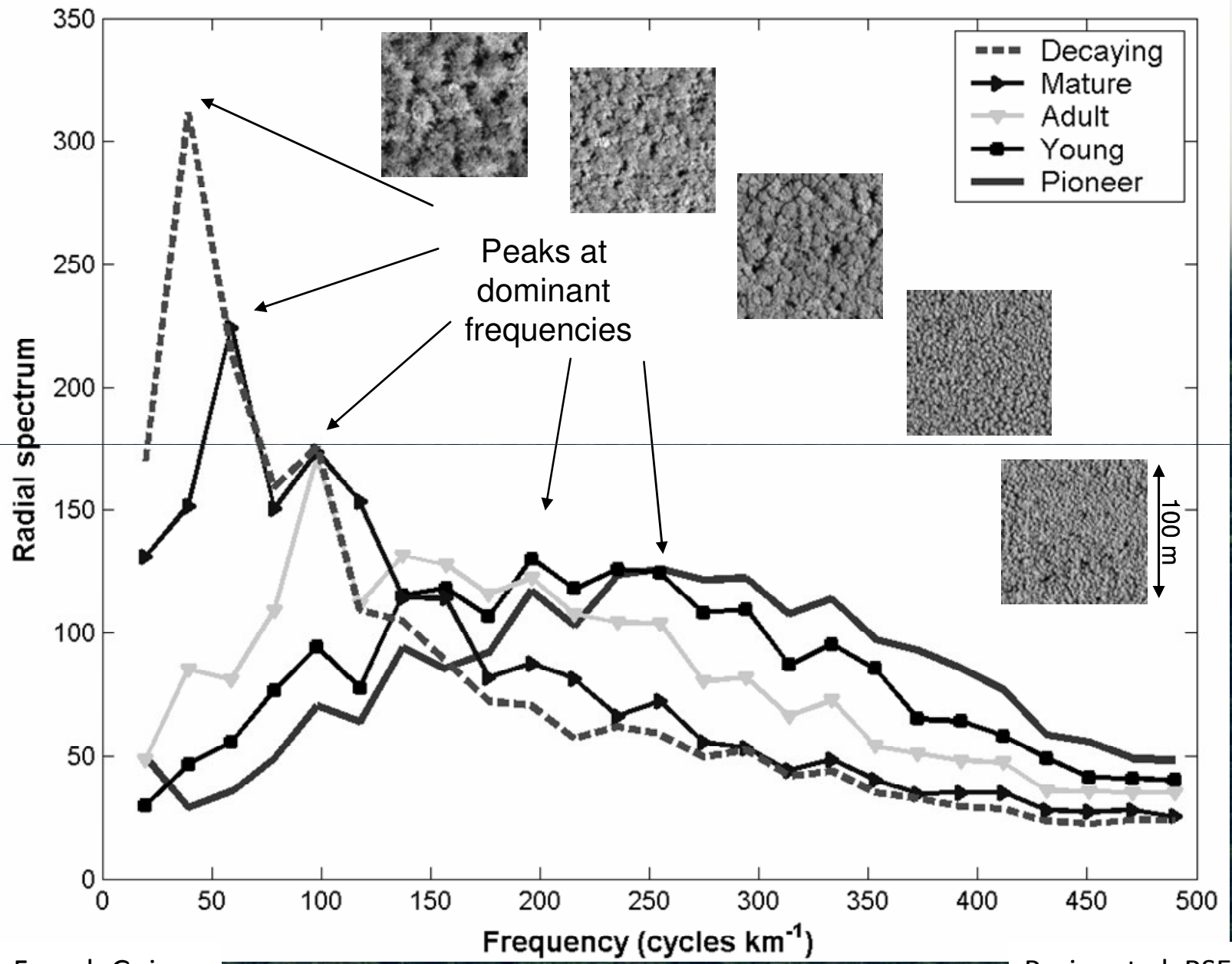
## Remote sensing methods

- **Limitation** of pixelwise optical and radar :
  - Saturation for high biomass levels (>250 t/ha);
  - Unable to detect degradation.
- High cost of airborne sensors (e.g. LiDAR).
- Potential of **VHR imagery** (Quickbird, Ikonos, etc.) but operational methodologies to be developed.



RCA: GeoEye pansharpened G-NIR-B

# Fourier periodograms: quantification of image texture



## 2D Fourier transform textural ordination (FOTO)

- 2D Fourier transform
- Radial power spectrum (r-spectrum)

= Proportions of the image variance accounted for by successive frequency bins, across azimuthal orientations.

- Principal components of image r-spectra dataset

= Identification of main axes of textural variation in the image dataset.

### Workflow:

**Imagery**  
(metric optical)  
Forest cover

**Unit-windows**  
100 - 150 m sides

Fourier analysis  
r-spectra computation

Frequencies

*Windows*  
**Table of r-spectra**

Separation into  
homogeneous acquisition  
groups

*Windows*

Global  
standardisation

**PCA ordination**

Partitioned  
standardisation

**Texture indices**  
(PCA 1, PCA 2)

Relation of Texture indices with  
forest parameters for a set of  
(DART) stands

**Inverted forest  
parameter**  
(e.g. mean crown size)

## Textural ordination: principal axes of variation

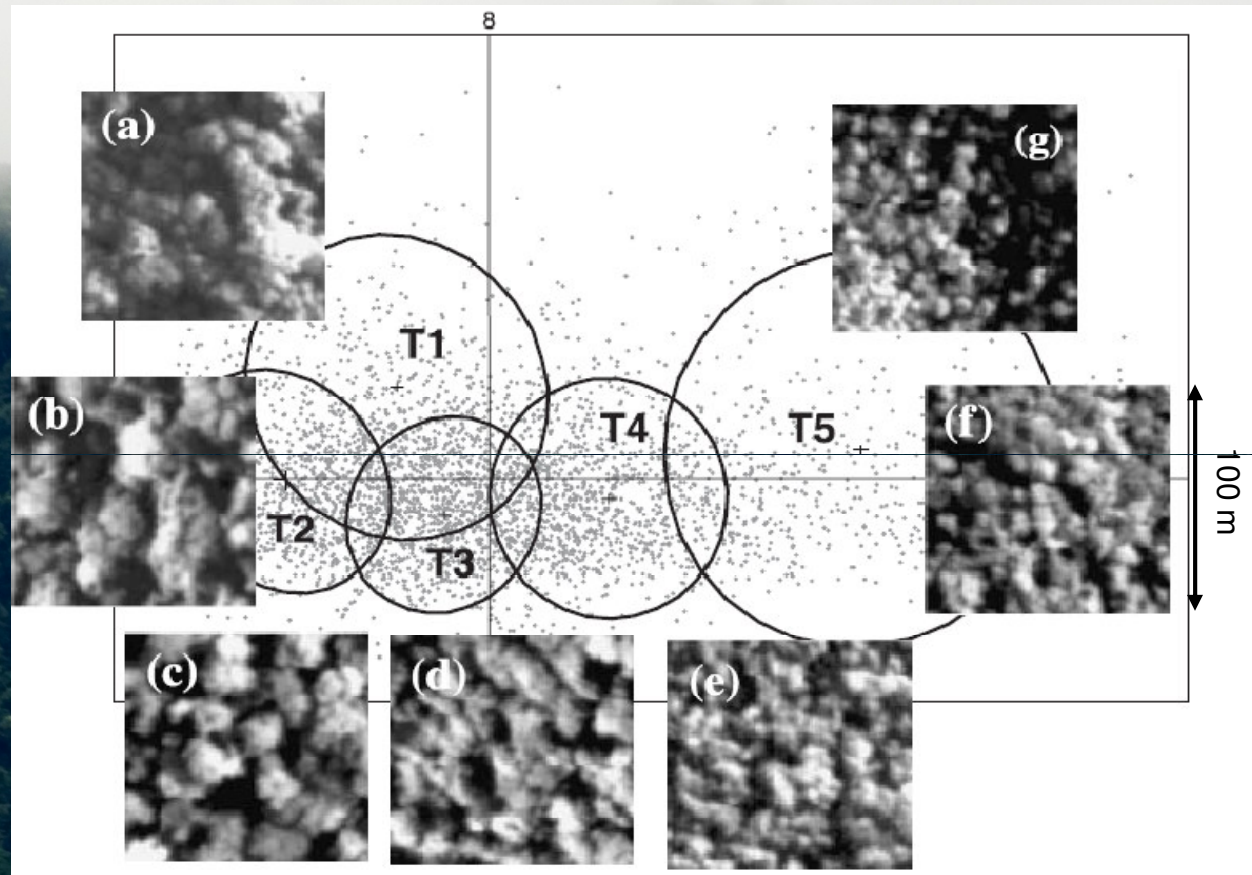
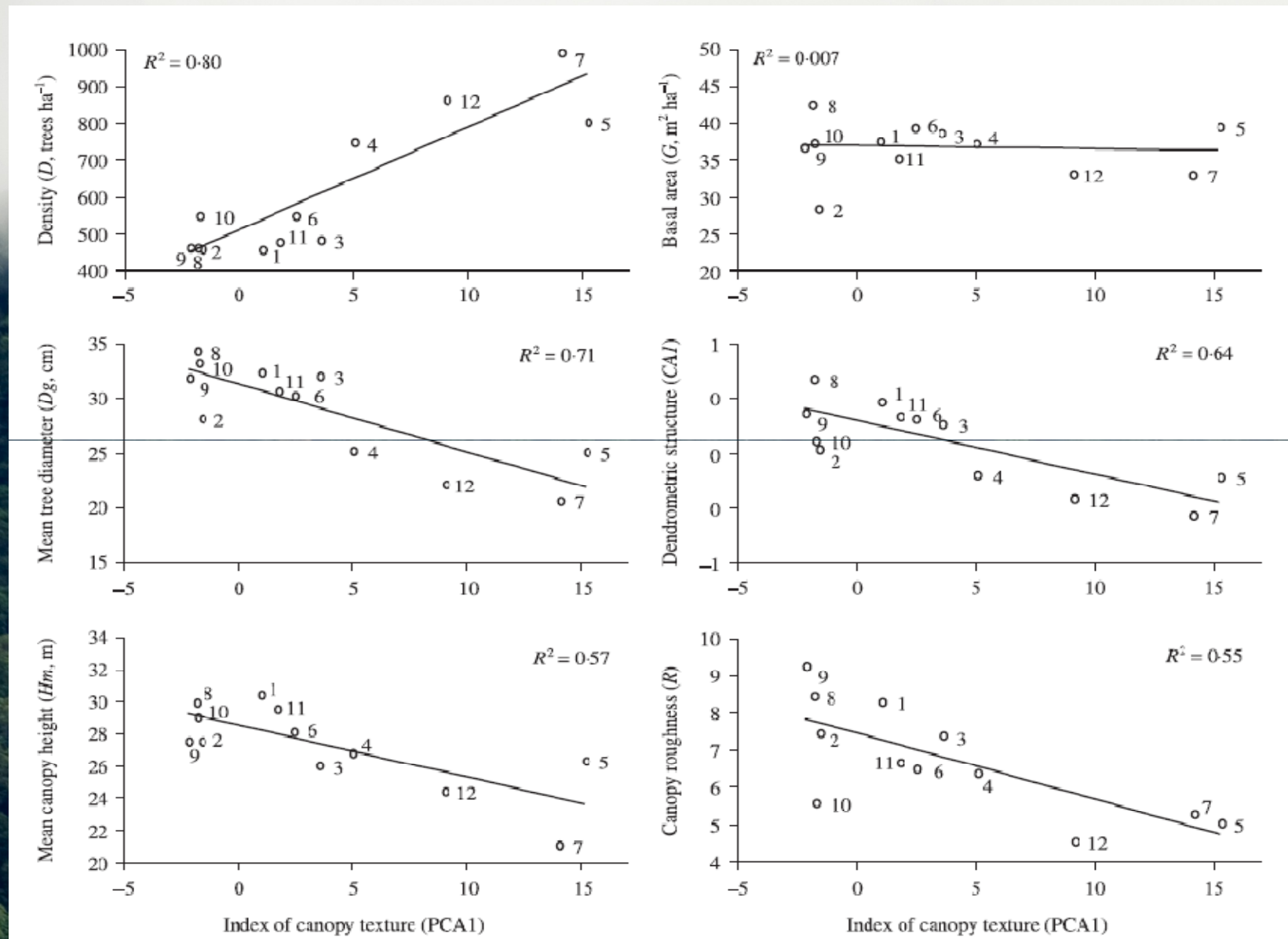


FOTO analysis on aerial photographs in French Guiana



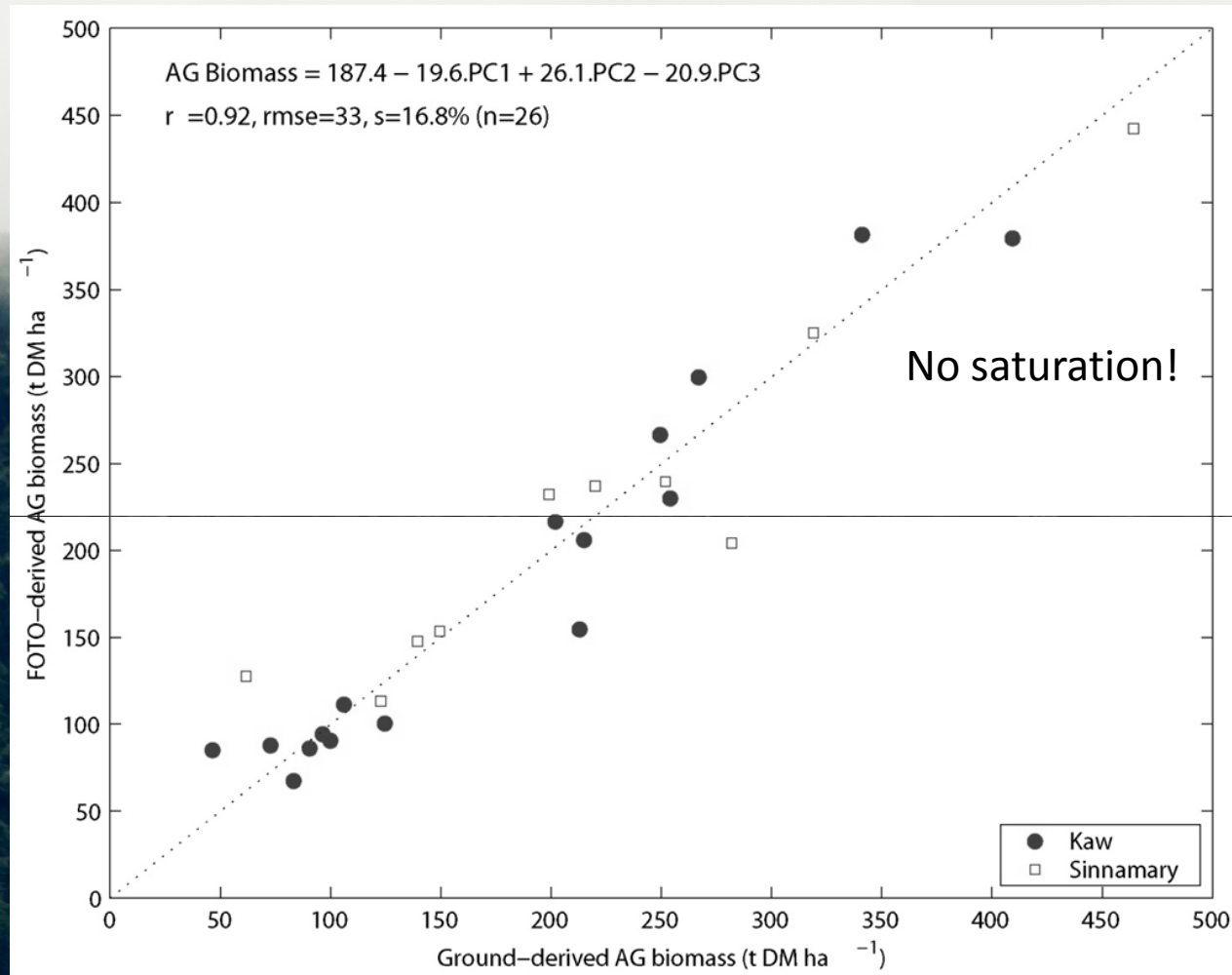
## Relationships with forest parameters



Terra Firme forest; French Guiana

Coutron et al. J Appl Ecol (2005)

## Relationships with forest parameters

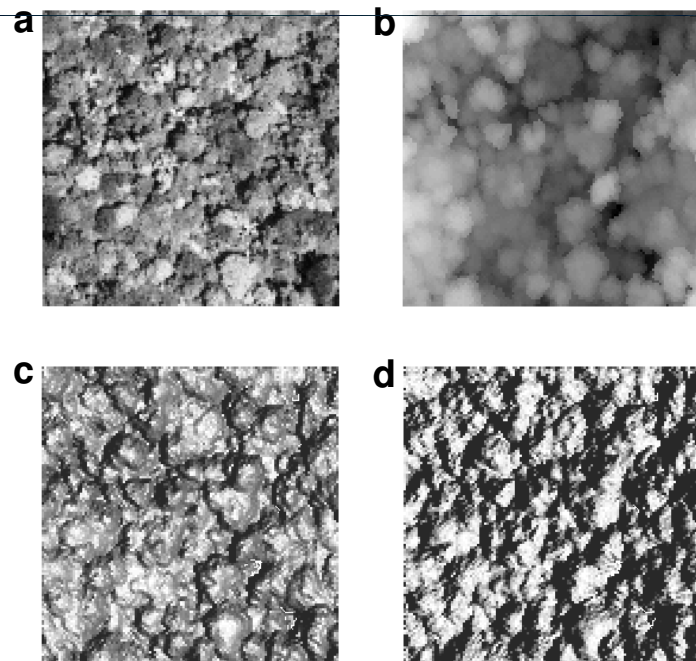
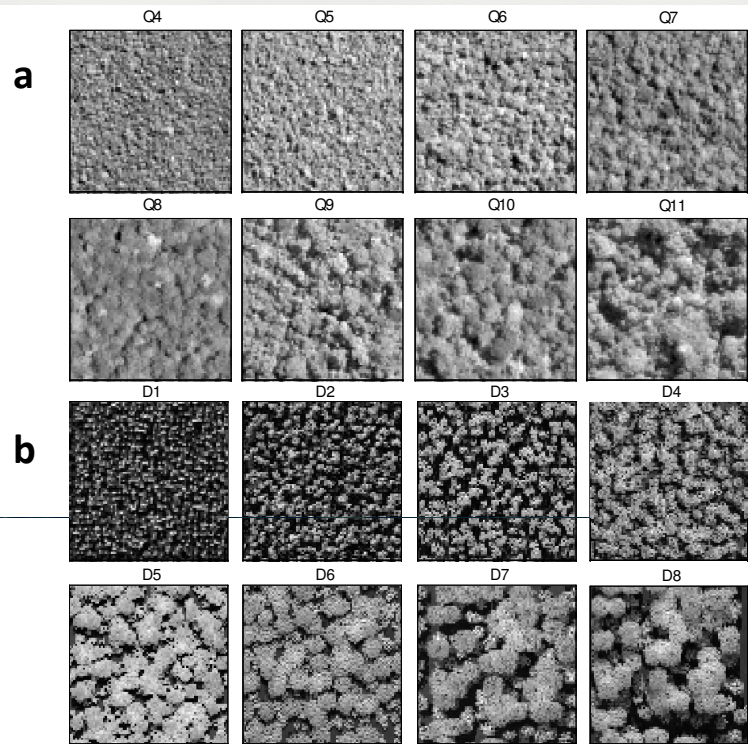


Biomass prediction using Ikonos imagery in mangrove stands; French Guiana

# Radiative transfer models

- Testing the effect of acquisition conditions
- Mitigation : partitioning method

a. Ikonos VHR.  
b. DART simulations

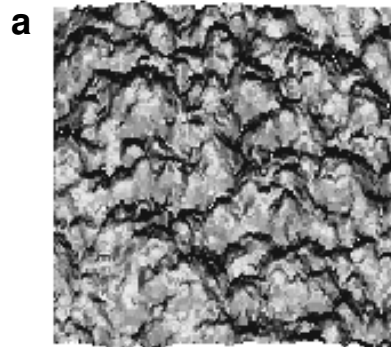


a. Ikonos VHR.  
b. LIDAR  
c-d. Hillshade models

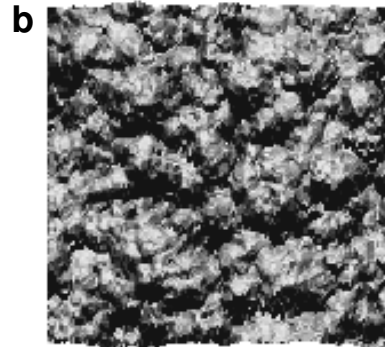


## Extreme configurations: typical examples

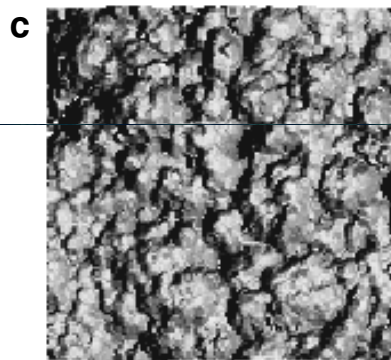
Hillshade effects on  
LiDAR surface models



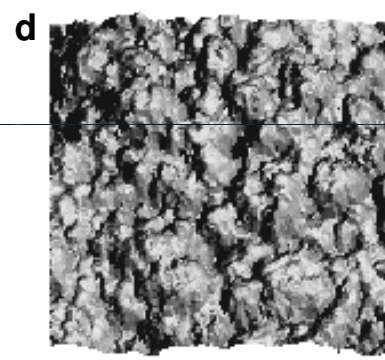
$$\phi_{s-v} = 0^\circ; \theta_v = 9^\circ; \theta_s = 59^\circ$$



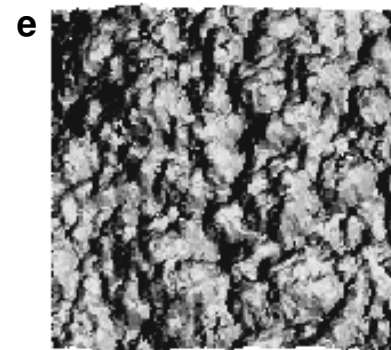
$$\phi_{s-v} = 180^\circ; \theta_v = 9^\circ; \theta_s = 59^\circ$$



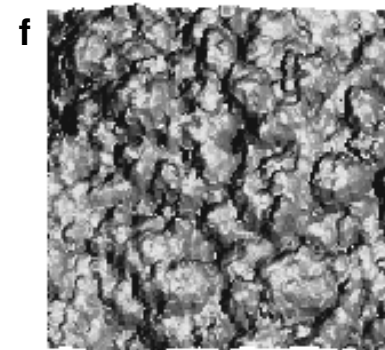
$$\phi_{s-v} = 80^\circ; \theta_v = 3^\circ; \theta_s = 59^\circ$$



$$\phi_{s-v} = 80^\circ; \theta_v = 15^\circ; \theta_s = 59^\circ$$



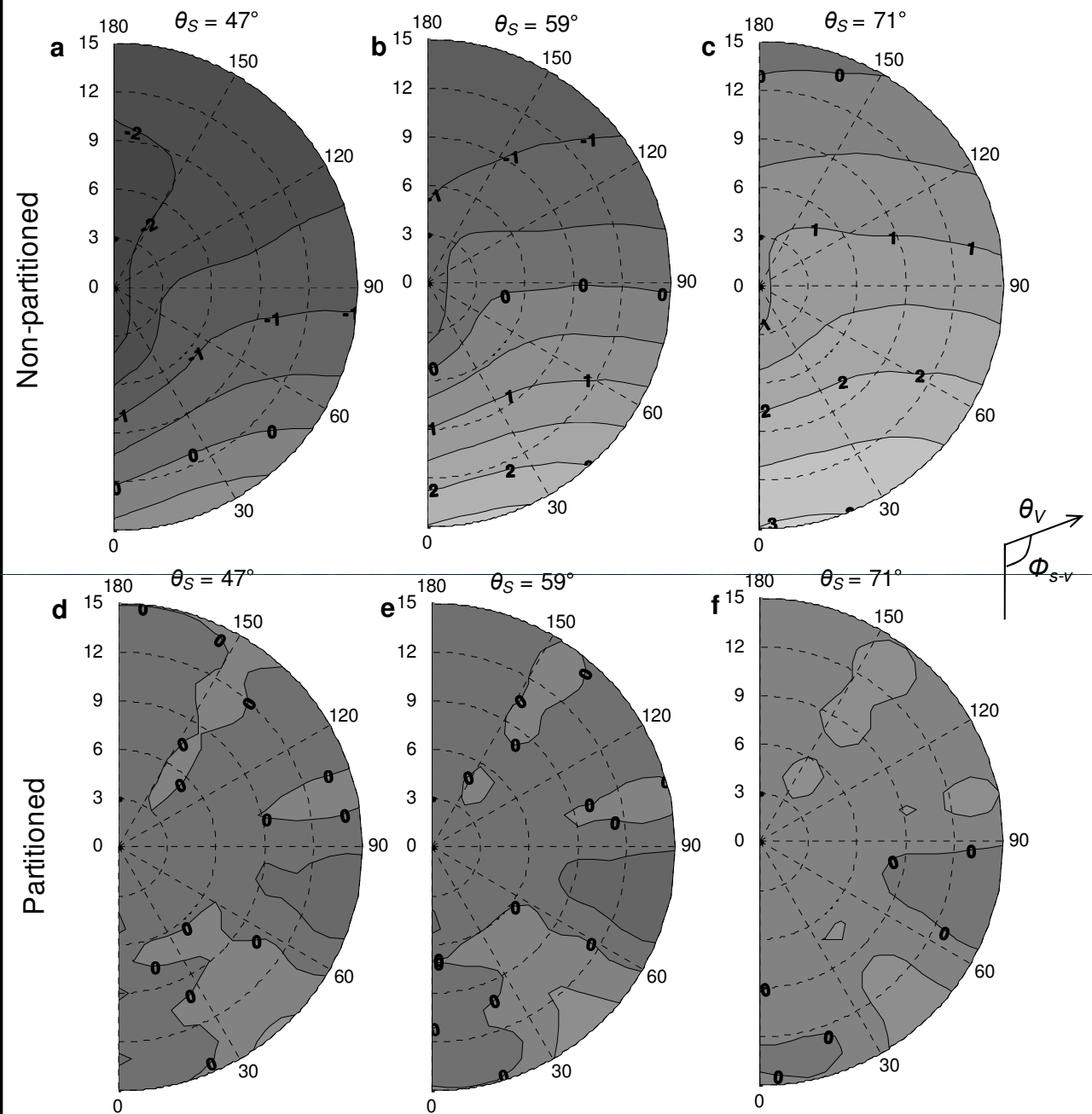
$$\phi_{s-v} = 80^\circ; \theta_v = 9^\circ; \theta_s = 47^\circ$$



$$\phi_{s-v} = 80^\circ; \theta_v = 9^\circ; \theta_s = 71^\circ$$

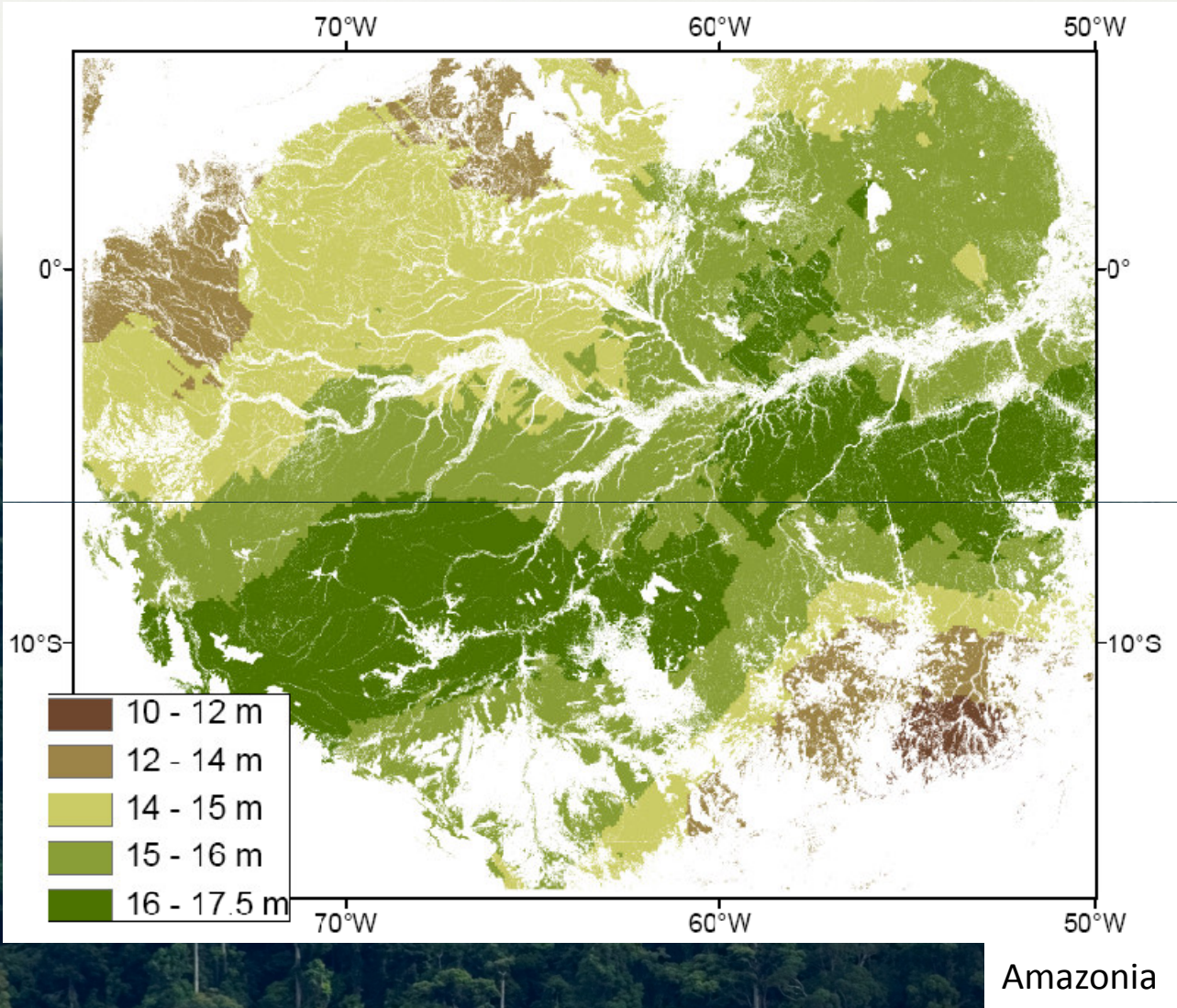
## Bi-directional texture distribution

- 'Hotspot' effect on texture,
- Alleviated by partitioning approach.



# Large scale application

## maps of apparent crown size and canopy heterogeneity



# Validation: the Canopy project

- Texture analysis: The FOTO method (IRD).
- Field validation: Large forest inventory database across Central Africa (FRM).
- Software development: Convivial interface in ArcGis (Nev@ntropic).

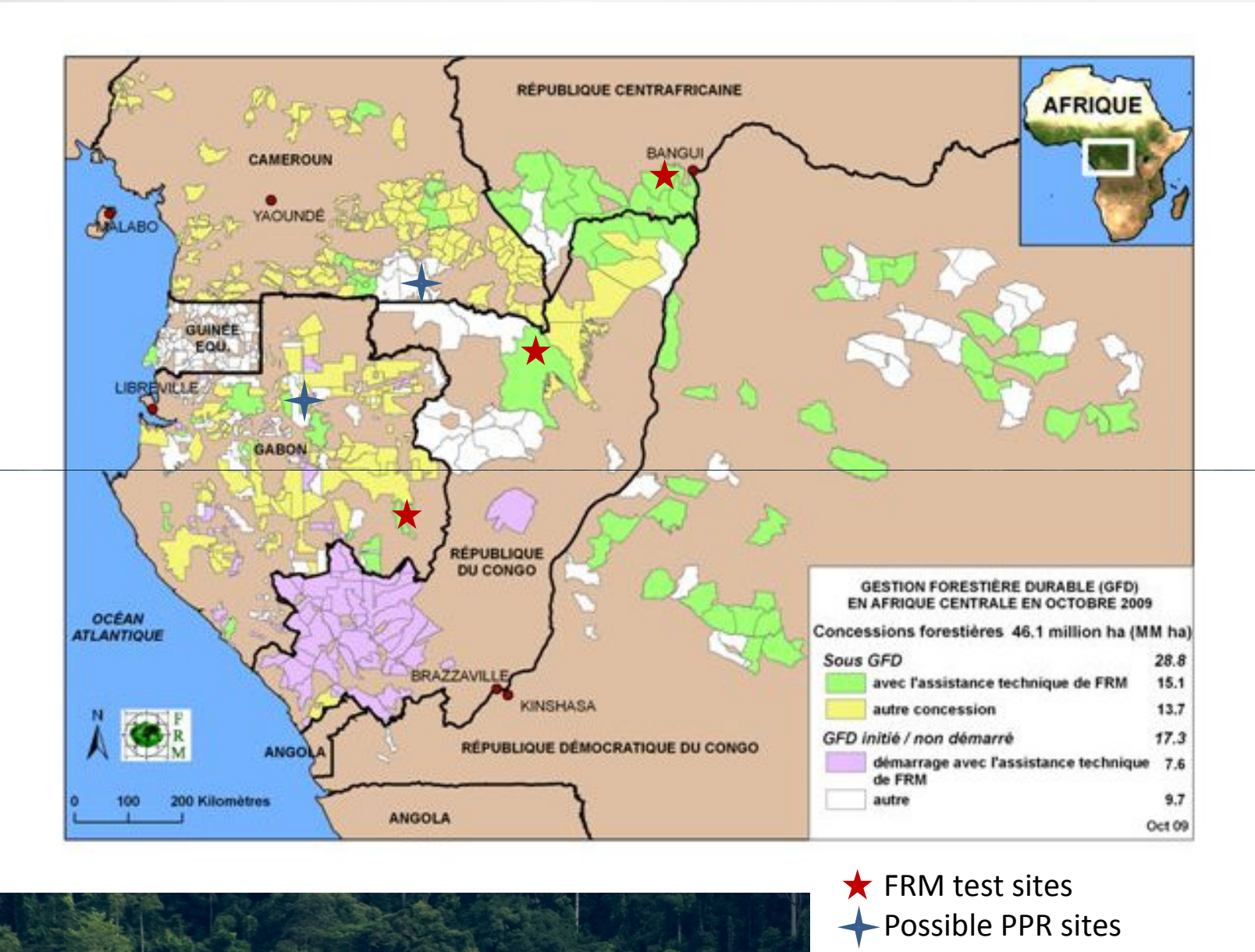
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# Large scale validation: test sites





## Imagery

- Planet Action: Spot 5, Formosat, Kompsat
- Others: Quickbird, Ikonos, GeoEye, Orbview

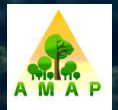


FOTO  
analysis

## Field Data

- Geolocalized plots of 0.5 ha
- Forest concessions above 50,000 ha
- Inventoried surface areas around 1%
- All trees above 10-20 cm diameter
- Destructive biomass sampling (upcoming)



# Perspectives

- Quantification of forest canopy structure.
- Valuable insights into :
  - **Degradation** level ;
  - **Biomass and carbon, with no saturation ;**
  - Other forest structural attributes.
- **Large scale** application and repeatable.
- Effect of **acquisition conditions mitigated.**
- **Relative low cost.**